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CONTENTS.

	PAGE
The Palæontological Case for Evolution. By R. Lydekker	73
Lord Kelvin's New Idea about Ether Atoms. By Dr. J. G. McPherson, F.R.S.E.	76
Cross-Fertilisation in Sociology.—II. By J. Collier	77
The Chemistry of the Stars. II.—Varieties of Spectra. By A. Fowler, F.R.A.S. (*Illustrated*)	79
Photograph of the Nebula round the Star DM. No. 980, Zone 34°, in the Constellation Auriga. By Isaac Roberts, D.Sc., F.R.S. (*Plate*)	81
Man's Place in the Universe. By E. Walter Maunder, F.R.A.S.	81
Letters:	
The Visibility of the Crescent of Venus. By W. T. Mackie. Note by J. N. Strassmaier, S.J.	83
The Cross of S. Sophia. By F. C. Burkitt. Note by E. M. Antoniadi	84
British Ornithological Notes. Conducted by Harry F. Witherby, F.Z.S., M.B.O.U.	84
Notes	85
Notices of Books	87
Books Received	88
St. Sophia, Constantinople.—III. By E. M. Antoniadi, F.R.A.S. (*Illustrated*)	88
Microscopy. Conducted by M. I. Cross	91
Notes on Comets and Meteors. By W. F. Denning, F.R.A.S.	93
The Face of the Sky for April. By W. Shackleton, F.R.A.S. (*Illustrated*)	93
Chess Column. By C. D. Locock, B.A.	94

THE PALÆONTOLOGICAL CASE FOR EVOLUTION.

By R. Lydekker.

At the date of publication of the first edition of "The Origin of Species," in 1859, the poverty of our palæontological collections—especially as regards the remains of vertebrates—the so-called "imperfection of the geological record," and the comparatively small area of the earth's surface which had been geologically examined, were regarded as reasons sufficient to explain the absence of evidence of any one definite line of descent of a modern from an ancient type of animal. In addition to this, it was pointed out that a very large percentage of the fossil vertebrates then known to science were represented by such fragmentary remains that it was almost, if not absolutely, impossible to arrive at any satisfactory estimate of their real affinities and relationships; and it seems to have been taken for granted that there was comparatively little hope of matters being materially mended in these respects in the near future. Moreover, the suggestion was hazarded* that one living mammal might be the descendant of a second, and that possibly the horse might trace back its ancestry to the tapir. Not a shadow of suspicion seems indeed to have existed at that time in regard to the ancestry of the horse (or, as we should properly say, the horse tribe), although, curiously enough, the chief stages in that line of evolution were already known to science.

Matters remained in much the same state till at least as late as the issue of the fifth edition of "The Origin of Species" in 1869. Twenty years later, however, when another important work on the same subject—Dr. A. R. Wallace's "Darwinism"—made its appearance, evolutionists were able to bring forward a much more formidable array of evidence in favour of their doctrine, especially in regard to vertebrates. During the two decades which had elapsed since the publication of the fifth edition of Darwin's great work, the marvellous discoveries in vertebrate palæontology made by Marsh and others in the north-western territories of the United States had come as a revelation to the zoological world; while the enormous number of mammalian remains brought to light during the working for commercial purposes of the valuable deposits of phosphorites in Central France had served to revolutionize our conceptions of the extent and relationships of the ancient Tertiary mammalian fauna of Europe. Marsh, ably seconded in this country by Huxley, had also been enabled to work out in detail the ancestry of the modern horse and its relatives (though the identity of the earliest member of the series with the little hyracothere discovered more than forty years previously in the London Clay was still unsuspected); and the descent of the modern rhinoceroses from primitive types of odd-toed mammals had likewise been demonstrated. Huxley, too, had made known the existence of many remarkable resemblances between the skeletons of birds and those of the extinct dinosaurian reptiles; while his account of the relationships of the ancient to the modern crocodiles afforded an important piece of evidence in favour of the evolution of animal forms.

It was still, however, a matter of reproach to those who supported the doctrine of evolution that so few phylogenies, or lines of descent, could be cited as firmly established on palæontological evidence. Huxley had indeed insisted (perhaps with rather too much emphasis) on the intimate relationship formerly existing between birds and reptiles on the one hand, and between salamanders and fishes on the other, but practically nothing had been learnt with regard to the affinities between mammals and other groups of the vertebrate stock. Again, the modern type of bony fishes were believed to have made their appearance suddenly in the Cretaceous epoch, and to have no connection with the earlier mail-clad fishes commonly called ganoids; although, it is true, the suggestion occurs in Dr. Wallace's book that certain reputed members of the latter group might prove to be much more closely related to the bony fishes than was commonly considered to be the case.

Since 1889 our knowledge of the mutual relationships of different groups of vertebrates, and of the phylogeny of particular families, as deduced from their fossil remains, has increased by leaps and bounds. And, so far as the specimens in our museums are concerned, we are now suffering from an *embarras des richesses* rather than from lack of material.

So far as we are aware, no attempt has been made of late years to lay before the general public in a popular manner some of the most striking features of the case for evolution as presented by palæontological evidence.

* *See* Fifth edition, page 347.

Although this is by no means an easy task, so far as vertebrates are concerned, it is the object of the present article. As regards the phylogeny of particular family groups of animals, attention is chiefly concentrated on mammals—the highest of all animals—but the subject would manifestly be incomplete without some reference to the evidence as to the mutual relationship of the primary groups into which the vertebrata are divided by naturalists. It is this portion of the subject which claims our first attention.

With regard to the evidence in favour of a genetic connection between vertebrates and lower forms of animal life commonly termed invertebrates, opinions at the present day are so divided and so little is known with certainty, that any lengthened discussion on this aspect of the subject would be unprofitable. It may be mentioned, however, that in the far distant epoch when the Old Red Sandstone of Scotland was being deposited there flourished in the lakes and rivers of the northern hemisphere a group of mail-clad, somewhat fish-like creatures of which the two leading types are collectively known as cephalaspids and pteraspids. A striking feature of these lowly creatures, and the one from which the former group takes its name, is the presence of a large shield covering the head-region, and in some cases taking somewhat the form of a cheese-cutter. Now this shield has a curious resemblance to the carapace, or shell, of a remarkable little freshwater crustacean known as *Apus*, which may be met with in ponds in this country. This resemblance is regarded by some palæontologists—Professor Patten among the number—as not due to accident (if we may use the expression), but as indicative of a true genetic relationship between the two groups. And the writer whose name is cited in the last sentence would even go so far as to say that we are justified in regarding vertebrates and arthropods (crustaceans, insects, etc.) as diverging branches of a common ancestral stock closely related to the cephalaspids. Whether this striking theory will be confirmed, or otherwise, time alone will show, but it serves to indicate that there is at least some kind of palæontological evidence in favour of the origin of vertebrates from lower types of animal life. Nor are others wanting, although space and other considerations do not admit of their discussion on this occasion.

We pass on, then, to consider the evidence in favour of the descent of mammals from lower types of the vertebrate stock.

Till comparatively recently it was supposed that salamanders—not the living forms, but their presumed ancestors, the labyrinthodonts of the Carboniferous and Permian epochs—were the nearest relatives of mammals, and, on the evolution hypothesis, the representatives of the parent stock from which the latter group originated. This idea was in great part due to the circumstance that while in reptiles (as in birds) the skull is articulated to the first joint of the backbone, or vertebral column, by a single knob—technically termed the condyle—in mammals and salamanders there are two such knobs or condyles. The single reptilian condyle consists, however, of three parts, a median and two lateral elements, as is well shown in the back view of the skull of a turtle. Now it is evident that by the loss of the median element, and the extra development of the two lateral parts, such a tripartite single condyle could quite easily be converted into the double condyles characteristic of mammals; and, as a matter of fact, there are indications how such a transformation has been actually brought about.

The possibility, or indeed the very existence of such a transformation would not, however, be sufficient to demonstrate the descent of mammals from reptiles. To prove this we have to rely upon the evidence afforded by a remarkable group of extinct reptiles which flourished during the early portion of the Secondary epoch of geological history, and attained a special development in South Africa, or at all events, have left a large series of their remains in that country. One of the most curious things about these anomodonts (or theromorphs), as they are called, is the similarity of their teeth to those of carnivorous mammals; the division into incisors, canines, or tusks, and cheek-teeth, or grinders, being just as well developed as in the latter. But it is not on this dental evidence, strong as it is, that we have alone to depend in affiliating mammals to anomodonts. In the first place there are certain very significant resemblances between the skulls of the two, more especially as regards the structure of the region of the cheek-bone. Of even more importance is the community of structure displayed by the bony girdles supporting the limbs of the anomodonts and the same portion of the skeleton in the living egg-laying mammals of Australia. In each, for instance, the haunch-bone consists of three precisely similar elements; and an equally remarkable resemblance is displayed by the shoulder-blade and the bones connected with the same in the two groups. It is not easy to make those unacquainted with anatomy thoroughly realise the importance of these structural similarities; but to the anatomist they are full of significance, and proclaim with no uncertain sound the existence of an intimate genetic relationship between the ancient anomodont reptiles and the modern monotreme mammals.

Dr. H. Gadow, of Cambridge, sums up the case concisely, as follows:—"Mammals," he writes, "are descendants of reptiles, as surely as the latter have been evolved from amphibia (salamanders and their kindred). This does not mean that any of the living groups of reptiles can claim this honour of ancestry, but it means that the mammals have branched where the principal reptilian groups meet, and that is a long way back." The anomodonts, or theromorphs, he adds, and especially the smaller representatives of the sub-group known as theriodonts, alone show us what these primitive—half reptile, half mammal—creatures were like.

But, it may be objected, the most mammal-like of these generalised reptiles were furnished with a full series of formidable teeth simulating those of the carnivora, whereas one of the two existing representatives of the egg-laying, or monotreme, mammals, namely the spiny ant-eater, is toothless, while the other (the duckbill, or platypus) has only a few teeth on the palate in early life, and these of an altogether peculiar and aberrant type. There can, however, be little doubt that some, at least, of the ancestral mammals were provided with a full series of differentiated teeth like those of the carnivorous anomodonts, although it is by no means certain that the modern egg-laying mammals are derived from such a type. Among the anomodonts, for instance, there occur certain forms with teeth not very unlike those of the duckbill, and it is thus quite possible that the latter animal and the spiny ant-eater trace their descent to a special branch of the anomodont reptiles.

For the ancestors of mammals other than the modern monotremes we may not improbably look to the small forms of which a few jaws have been met with in the Stonesfield Slate of Oxfordshire. That these early mammals were the direct descendants of the anomodonts there can be little hesitation in admitting; and it is also quite within the bounds of probability that they laid eggs. Unfortunately, however, our knowledge of these Jurassic mammals is of the most vague and unsatisfactory nature; this being mainly owing to the extreme rarity and frag-

mentary condition of their known remains. Possibly this may be accounted for on the supposition that the evolution of primitive and presumably egg-laying mammals from anomodont reptiles did not take place in Europe, or indeed anywhere in the northern hemisphere; so that the few remains with which we are acquainted were probably derived from individuals which had strayed far away from the headquarters of the group. Nothing is indeed more likely than that Africa was the region where the anomodonts developed into egg-laying mammals; and it is to that continent more than to any other part of the world that we may look with the most hope to the discovery of a full series of the intermediate forms between reptiles and mammals.

There is, indeed, a very great and very serious "imperfection of the geological record" in regard to the origin of mammals. For after leaving the rich anomodont fauna of South Africa, nothing is known of mammalian development and history save such imperfect information as can be gleaned from the aforesaid jaws from the Stonesfield Slate, and others from the Purbeck deposits of Dorsetshire, and the Triassic, Jurassic, and Cretaceous rocks of the United States, till the early part of the Tertiary period is reached. Then we come suddenly upon an abundant and well differentiated mammalian fauna widely spread over the northern hemisphere. The immediate ancestors of this fauna we have yet to find.

Nevertheless, in spite of this very large gap in our knowledge, the information we already possess is, as mentioned above, amply sufficient to demonstrate the close affinity existing between mammals and the anomodont reptiles, and to justify the assertion that (if evolution be the true explanation of animal resemblances) the one group is the descendant of the other. The thread of mammalian development will be taken up again in a later paragraph; but before this is done, a few words must be devoted to the other main groups of mammals.

In the passage from Dr. Gadow's paper quoted above it is incidentally mentioned that as reptiles have given origin to mammals, so they themselves are the offspring of amphibians, or salamanders. And here, somewhat curiously, we must once again refer to anomodonts. Among the more mammal-like types in this group the skull is vaulted, with the temporal region open, and the component bones smooth, while the limbs were elongated and adapted to raise the under surface of the body well above the ground. On the other hand, there are certain members of the group in which salamander-like features predominate, the skull being depressed and expanded, with the temporal region roofed over, and the cranial bones sculptured externally, the limbs being short, so that the under side of the body touched the ground.

We thus have an approximation between the anomodonts and the primeval salamanders, or labyrinthodonts, although the exact nature of the relationship is at present somewhat obscure. The labyrinthodonts, or, as they are often called, stegocephalians, display, however, an almost complete passage into reptiles; so much so, indeed, that certain American Permian forms (*Eryops* and *Cricotus*) are placed by some writers in the first group and by others in the second. Among the most salamander-like of true reptiles are certain small forms (such as *Hylonomus*) from the Carboniferous and Permian; these in their turn pass into still more advanced types, such as *Protorosaurus* of the upper Permian, and *Palæohatteria* of the Trias, and from these latter there is an almost unbroken transition to the New Zealand tuatera lizard (*Sphenodon*), by far the most primitive and generalised of all living reptiles.

Regarding the connection between salamander-like amphibians—more especially the labyrinthodonts, or stegocephalians—and fishes on the one hand and reptiles on the other, we may once more, with slight verbal alteration, quote from Dr. Gadow,* who writes as follows:—"There is no doubt that the Amphibia have sprung from fish-like ancestors, and that they in turn have given origin to the Reptilia. The Amphibia consequently hold a very important intermediate position. It was, perhaps, not a very fortunate innovation when Huxley brigaded them with the fishes as Ichthyopsida, thereby separating them more from the Sauropsida (reptiles and birds) than is justifiable—perhaps more than he himself intended. The connecting link, in any case, is formed by the Stegocephalia; all the recent orders, the burrowing cæcilians, salamanders and frogs, are far too specialised to have any claims to the direct ancestral connections. The line leading from the Stegocephalia to fossil reptiles, notably to such Proreptilia as *Eryops* and *Cricotus*, and even to the Prosauria (*Hylonomus*, *Palæohatteria*, etc.), is extremely gradual, and the steps are almost imperceptible. Naturally, assuming evolution to be true, there must have lived countless creatures which were neither Amphibia nor Reptilia in the present intensified sense of the systematist. The same consideration applies equally to the line which leads downwards to the fishes. But the great gulf within the Vertebrata lies between fishes and Amphibia, between absolutely aquatic creatures with internal gills and 'fins,' and terrestrial quadrupedal creatures with lungs and fingers and toes."

Since, as indicated in the closing sentence of this passage, direct palæontological evidence of the descent of salamanders from fishes is at present wanting, we shall say no more with regard to those groups, except that the indirect evidence, as Dr. Gadow points out, is of itself sufficient to indicate the former existence of intermediate types. We accordingly pass on to the fourth great group of vertebrates, the birds.

That modern birds come closer to reptiles than to any other vertebrates is indicated by Huxley's scheme of brigading the two groups together under the common title of Sauropsida, to which allusion has been already made in this article. To describe their common features in detail would be quite out of place on the present occasion, but it may be pointed out that both groups agree in having a single condyle on the skull for articulation with the first segment of the backbone, as well as in the ankle-joint being situated in the middle of the tarsus instead of at the upper end, and also by the frequent presence of what are called uncinate processes to the ribs, and of a ring of bony plates in the white of the eye. A certain approximation to the reptilian type is, moreover, made by the lizard-tailed birds (*Archæopteryx*) of the Jurassic strata in the retention of the long tail from which they derive their popular title, as well as by the presence of claws on two of the digits of the wing, and of teeth in the jaws; teeth being also retained in several, if not all, of the birds of the succeeding Cretaceous epoch. Nevertheless, *Archæopteryx* is in all respects essentially a bird, and in no sense an intermediate form between birds and reptiles.

There are, however, certain extinct reptiles, the Dinosauria, many of whose members habitually assumed an upright posture, which exhibit much more decided structural resemblances to birds than are presented by any modern reptiles. One of the most remarkable of these resemblances occurs in the bones of the hind-leg, in which the upper part of the ankle, or tarsus, tends to unite itself with the leg-bone, or tibia, thus simulating the tibio-tarsus, or leg-bone of a bird. On the other hand the lower half of the tarsus displays an equally marked

* "Cambridge Natural History—Amphibia and Reptiles," p. 5.

XUM

tendency to coalesce with the upper bones of the foot. Nor is this all, for the latter bones—the metatarsals of the anatomist—in some cases are partially coalesced, so as, in conjunction with the lower half of the ankle, to approximate to that very characteristic bone of a bird's leg the tarso-metatarsus. Moreover, there are decided resemblances between the haunch-bones, or pelvis, of dinosaurs and birds.

It was largely on the evidence of the dinosaurian skeleton—especially that of some of the smaller members of the group—that Huxley was induced to brigade birds and reptiles together as Sauropsida. When this generalisation was made, the modern doctrine of parallelism in development was not recognized as an important factor in evolution; and since its recognition doubts have been expressed whether the skeletal resemblances between birds and dinosaurs may not be due to this cause rather than to direct genetic affinity between the two groups. By parallelism in development, it may be explained, is meant the production of more or less nearly identical structural peculiarities by adaptation to similar, or somewhat similar modes of life; or perhaps, in some instances, to a general progressive evolution towards a higher structural type. One of the best instances is afforded by the cases of the horses and the prototheres, to which attention is devoted in the sequel.

With a full knowledge of the important part played by parallelism in development before him, Prof. H. F. Osborn,* of New York, has recently reconsidered the evidence in favour of the existence in the Permian period of a common ancestral stock from which have diverged dinosaurs and birds. While admitting that many of the resemblances between these groups are adaptive rather than genetic, and believing that the apparent close correspondence in the structure of the pelvis between adult birds and the herbivorous dinosaurs (which are specialised types) is due in a considerable degree to a misinterpretation of the homology of some of their elements, Prof. Osborn nevertheless argues that the resemblances between the two groups are so numerous as to justify the belief of kinship. Special importance is attached to the opinion that some sort of bipedalism was a common character of all dinosaurs, the suggestion being countenanced that certain forms, like *Stegosaurus*, have reverted from a bipedal to a quadrupedal mode of progression. Our present knowledge, he concludes, therefore, justifies us in saying that "in this bipedal transition, with its tendency to form the tibio-tarsus, the avian phylum may have been given off from the dinosaurian. This form of the Huxleyan hypothesis seems more probable than that the avian phylum should have originated quite independently from a quadrupedal proganosaurian [prosaurian] reptile, because the numerous parallelisms and resemblances in dinosaur and bird structure, while quite independently evolved, could thus be traced back to a potentially similar inheritance."

Although to the lay reader his mode of expression may appear somewhat unnecessarily technical and abstruse, if not, indeed, in certain respects, absolutely cryptic, there is no doubt from the foregoing observations that Prof. Osborn inclines to the belief that birds are in some manner genetically connected with the dinosaurian reptiles, although, from the existence of fully differentiated birds at such an early epoch as the upper Jurassic, the date of divergence must have been extremely remote, possibly as far back as the Permian.

Before leaving this portion of the subject, a word is advisable with regard to the flightless birds of the ostrich group. Not very many years ago it was considered that this group was the oldest and the one nearest akin to the extinct dinosaurs. It is now, however, quite evident, if only from the structure of their degenerate wings, that the ostrich-like birds, in place of being their ancestors, are themselves descended from forms endowed with the power of flight—whether from more than a single group we need not now pause to enquire. It is true that in certain respects their skeletons come nearer to the dinosaurian type than is the case with those of their flying relatives. But their resemblance—either by parallelism in development, or by reversion to the common ancestral type—may probably be explained by their mode of life being more like that of dinosaurs, and perhaps in part by the large bodily size of the majority of the group.

(To be continued.)

* *American Naturalist*, October, 1900.

LORD KELVIN'S NEW IDEA ABOUT ETHER ATOMS.

By Dr. J. G. McPherson, F.R.S.E.

Lord Kelvin, President of the Royal Society of Edinburgh, startled the Fellows, on the evening of the 19th January, with his new idea about ether atoms, in his exposition of the reflection and refraction of light. He has been for years met by serious difficulties in carrying out the practical conclusions of the undulatory theory of light; and these difficulties he exposed in detail.

One investigator after another he found to make ingenious suggestions on the old lines. But Fresnel, Green, Voight and others, with all their ingenuity, could not account for certain discrepancies. But Lord Kelvin, with a master hand, has dispelled all these difficulties by a direct denial of a tenet of the Schoolmen that "two bodies cannot occupy the same space at the same time." Paradoxical as it appears, he assumes the opposite, that two bodies can occupy the same space. That is his main and fundamental tenet, and by it he is able to clear the air of what, for a quarter of a century, has interfered with his coming to satisfactory conclusions on light and electricity.

Leucretius was right in saying, two thousand years ago, that matter was not infinitely divisible, but that atoms and the void constituted matter. These atoms, he considered, were indivisible, originally moving in parallel lines. His fallacy was in assuming that an atom had the inherent *facul* of changing the direction of its motion, so that, by interrupting the parallel lines of motion of the atoms by the alteration of direction at some point, atoms were brought together out of the void to form matter. Yet Leucretius did not dream with his fallacy; for Lord Kelvin, though discarding any idea of the quasi-living power of the atom to change the direction of its motion, assumes that there is an *electrion*, or electric atom within the material atom.

Lord Kelvin assumes that, *prima facie*, according to the laws of dynamics, the material atom is of a spherical form. But this atom is permeated by the ether atom, both occupying the same space. Though the electrion is not material, the ether atom is material, of the fine jelly constituency, infinitely incompressible, though easily changeable in form.

He illustrated the combination of the ether and ordinary material atoms in one spherical form and place by simple experiments. If a piece of common shoemaker's rosin be hung in water, and an iron bullet be placed on the top surface of the hard rosin, the bullet will, through time, slip inside the rosin. If, again, a spherical piece of cork be placed under the rosin, it will work its way up into the rosin, just as the iron bullet wrought its way down.

The spherical atom of matter is not homogeneous, but it is heavier at the centre than near the surface. Accordingly, when an ether current comes upon the spherical surface of the material atom it acts differently from the case of coming upon an ether atom. In the latter case, it would pass right through without change of direction. In the former case, the direction of motion would be attracted for a time nearer the centre of the atom, on account of the greater density there, and again reach the opposite side of the sphere, finally issuing from the surface of the sphere in the original direction of motion.

The electrion is the marvellous worker in the atom of matter, permeated by the ether atom. It is not always a unit, it may be one, two, or more, but up to nine will account for all the variations of motion, in unstable circumstances; yet there may be hundreds all within the one material atom. Nine he considers the necessary maximum, though one may, in certain circumstances, suffice. This electrion, with the self-occupancy of the ether atom and material atom, is the new means which he has secured for explaining away the difficulties which he has for long experienced in accounting for certain details in polarized light.

This is a bold stroke, and we must wait with patience until his remarkable paper is published, in which he gives startling details to undermine much of what has been done by writers on Light. He holds to Newton's law of gravitation, that one body influences another body, though not in contact, but he requires his new idea of the combination or self-occupancy in the same space of the jelly-like ether atom and the spherical material atom.

Even this outline must interest our readers. Without diagrams, and these would be imperfect, I could not give them an accurate idea of the facility of the explanation of the undulatory theory of light in reflection from a perfectly polished silver plane, and in refraction through the diamond, ordinary glass, and water. These Lord Kelvin illustrated by curves, showing the inaccuracy of the curves made by former observers and the accuracy—as tested by experiment—of the results of his hypotheses.

CROSS-FERTILISATION IN SOCIOLOGY.—II.

By J. Collier.

Individual Fertilisation.

Immigrant individuals initiate or continue the work of groups or masses. A few striking examples may be as convincing as a long list. Dynasties are often founded by immigrants. A Suabian cadet founded the house of Hohenzollern, and his type of character has proved persistent through all alliances, manifesting itself as plainly in the present vigorous ruler as in any of his ancestors. By a kind of moral transfusion the solid qualities of the race have passed into the people, which is likewise marked by courage, prudence, thrift, simplicity of life, a firm grasp of reality, and a total estrangement from German dreaminess and confused vision of reality. With these attributes kings and people together have expanded a slender nucleus into a powerful state, and made that state the heart and brain of Germany. A single woman carried into France in the sixteenth century the impure blood of the Medici. Keen observers have detected in the portraits of her sons the prepotency of the strong Italian house over the brilliant lineage of Francis I. Is it possible to mistake the same prepotency in the history of the following reigns? At a time when France was wavering between Catholicism and the Reformation, Catherine and her sons assured the predominance of the old religion. Corsican Napoleon re-made France in his own image. The Cisalpine house of Savoy built up the Transalpine kingdom of Italy. Noble families, too, have introduced a new strain into their adopted country. The German Colonnas in Italy were long and strenuously anti-Papal; the Savoyard Colignys nearly succeeded in carrying France over to Protestantism; the Italian Broglies, though doubly crossed with Protestant houses, have, on the whole, exercised a reactionary influence in France; the Savoyard Sainte-Aldegonde was the author of the Compromise of Breda with which began the war of independence in Holland; and another Savoyard, Bonnivard, heralded the reformation in Switzerland, and the independence of his country. Great statesmen have sometimes given a new political complexion to their adopted country. Mazarin saved the unity of France. Beaconsfield added prestige to Imperialism, and created a new England that some of us no longer know. The Duc de Richelieu was the founder and ruler of Odessa. Bolivar was no Peruvian. Political leaders, such as Kossuth and Strossmayer, were foreigners. Great discoverers, from Columbus to De Brazza, are often foreigners. Four Danes excited original developments in Prussia. Repaying the debt of France to Maurice of Saxony, Moltke made advances in the art of war that assured victory to Prussia and afterwards to Germany. Niebuhr created a new historical method, to which Mommsen gave ascendency. George Brandes has acclimatised cosmopolitan criticism in Berlin. The arts have everywhere been transmitted by immigrant artists. Two examples will perhaps serve where hundreds could be given. Lulli, with the aid of Quinault, founded Italian opera in France, and from their joint product descends the characteristically French opera, Gounod's "Faust." Spontini carried Italian melody to Germany, and there married it to the German genius for harmony, represented by Weber, and from these two have sprung Mozart's "Don Giovanni," and the more characteristically German operas of Wagner. An equally pointed instance will show how cross-fertilisation acts in science. The Italian astronomer, Cassini, made in Paris the first observations for measuring the earth. In company with the Abbé Picard he began the tracing of the first meridian, which Picard continued, and from the measurement of the degree given by Picard, Newton calculated the force that retains the moon in her orbit. The more recent names of Tadema and Herkomer, of Panizzi and Libri, Mohl and Max Müller, out of hundreds in all countries, will suggest how much all departments of human activity are fertilised by blends. Sometimes immigrants merely strengthen an existing tendency. The Saxons Ranke and Treitschke, transplanted to Berlin, became "more Prussian than the king," and the Suabian Hegel buttressed Conservatism in the same country. Lastly, prelates like Bessarion and Ximenez, and such monarchs as Francis I. and Louis XIV., Isabella of Spain and Catherine dei Medici, the Czar Peter, the Czarina Catherine, and Frederick the Great, who import artists, men of letters, and savants, resemble the botanists who place the pollen of one plant on the stigma of another, or the breeders who artificially pair varieties.

Degenerate Modes.

We have already passed insensibly into a new order of facts. Fertilisation by masses and groups was brought about by the actual mingling of two stocks. Fertilisation by individuals is often physical; the Colignys and the Colonnas, the Savignys and Chopins, the Roscoes and Rossettis, are the offspring of crosses between immigrants and natives. But many immigrants of genius are either celibate or sterile. Mazarin, Disraeli, and Moltke were

XUM

pure-bred, and though all three left behind them offshoots of their race, they themselves added not a drop of alien blood to their adopted countries, any more than did the host of missionaries, from Mahinda and Boniface to Moffat and Damien, to the countries they evangelized. Their action was purely spiritual. Spiritual action is the mimicry of physiological action; nevertheless, it too is genuine. A thinker's thoughts, an artist's works, a statesman's deeds, are as children born to him, and the transformation they accomplish becomes physiological in turn. The modes of cross-fertilisation still to be described are of this order.

The female of many animal species goes in search of the male, or at least throws herself in his way. From Plotinus to Postel, and from Burnouf to Mrs. Besant, sages, scholars, and seekers have gone on pilgrimage to the East to discover the secrets of existence or the materials of science. Mediæval students flocked to Paris, and the fertility of Scholasticism is doubtless due to the German, Italian, and English crosses with the French intellect. Young Castilians southed to Granada to learn courtly manners, as the young English used to do the grand tour, and Spanish ceremony may owe its stateliness to the instruction. The English, French, and German scholars of the Renaissance pilgrimed to Italy. Painters and sculptors of all countries frequented Rome, as now Paris. New species are thus begotten. Again a few examples must suffice.

Almost all the pre-Revolutionary thinkers of France had visited England, and had studied its constitutional liberties, its science, philosophy, and free-thought. Montesquieu spent two years in our country, and every page of his chief work bears witness to the fertility of the contact. Voltaire came to England "to learn to think," and passed three years in constant intercourse with its greatest writers. His debt to English thought has perhaps been overstated. M. Brunetière has conclusively shown that Voltaire's scepticism was of earlier date than his visit to England, and in fact he but continued an old French tradition. But it cannot be doubted that his native tendencies were stimulated by acquaintance with Bolingbroke and English deists. Not less fruitfully he became the expositor of the Baconian logic, the Newtonian physics, and the Lockian psychology. English notions of liberty and canons of criticism passed into the French mind. Mr. Lecky does not exaggerate in describing this interaction as the junction of the French and English intellects.

The Baptist of the modern renaissance of art was Johann Joachim Winkelmann. A deep affinity for Hellenism in both intellect and temperament led him to the study of Plato, the inspection of casts from the antique at Dresden, and finally to Rome. There he accomplished his "finding of Greek art." All who have since transfused the old Hellenic spirit into literature and faith, art and life, descend from him. No more scientific language than Hegel's can be used to describe his generation of a new variety:—

> "By contemplation of the ideal works of the ancients, Winkelmann received a sort of inspiration through which he opened a new sense for the study of art. He is to be regarded as one of those who in the sphere of art have known how to initiate a new organ for the human spirit."

Under the grey skies of Sweden, Fogelberg, like Mignon, dreamed of the South. A dying Swedish sculptor told him that in Italy alone he should find true beauty. He had sought to achieve a Balder, a Thor, an Odin, and had failed; he needed the fertilising contact with Greek art. After some years' study in Italy he produced an *Odin*, which Gustave Planche describes as the offspring of "a happy alliance between the Swedish genius and the antique genius." It is a new type, a genuine creation. His *Thor* and *Balder* are similarly two original types, neither Greek nor medieval, whose conception is Scandinavian, while the expression is Greek.

Thorwaldsen spoke of himself as having been born on the day he entered Rome, when he was twenty-seven years old; till then, he said, he did not exist. The influence of Rome transformed a skilled artisan into a sculptor. His principal merit, according to Vicomte Delaborde, lay in combining the ancient style with modern sentiment. He expressed modern ideas and new or revived themes according to Greek methods, discovered by intuition and not by learning. He went back to an earlier period of Greek art than had previously been imitated, and, with an irresistible force of assimilation, he incorporated its substance and penetrated its spirit. Michel Agniolo had, in just the same way, founded the sculpture of the Renaissance. More consciously and systematically, Flaxman and Ingres arrived at similar results.

The extent to which this mode of cross-fertilisation still prevails in scholarship will appear from the fact that, in 1900, over 2500 foreigners were entered on the books of German universities. Of these 736 were Russians, in whom the ardour of conquest is equalled by the ardour of discipleship. The Russians are at once female to higher and male to lower races.

Secondary Agencies.

1. The insects, birds, and mammals that carry pollen and seeds to other plants and countries, have their analogues in the chapmen and travelling merchants, navigators, pilgrims, and missionaries, who convey books, works of art and industry, germs of religious ideas and political movements. It is a degenerate mode of fertilisation, being far slower and less efficacious than the local presence of immigrants, but its effects are identical. Native species are modified, if less deeply, and new species are transplanted, though they, too, undergo modification. An ancient and a modern example may be adduced. Phœnician merchants undesignedly introduced into Greece the Egyptian alphabet and art of writing, and thus founded the culture of Europe. The first seeds of Christianity were planted, half unconsciously, by the pirate-merchant Vikings, who returned to Scandinavia after a long sojourn in Christian lands.

2. The winds and marine currents that likewise transport seeds have their congeners in the world-rivers and commercial routes, and their analogues in the ships, caravans, and vehicles by means of which the bulk of modern propagandism is accomplished. Wind-fertilised plants are believed to be degraded specimens of insect-fertilised plants, and the intellectual influences conveyed through books and casts, though often vivid and powerful, are faint in comparison with the direct action of teachers immigrant or resorted to. Two illustrative instances might be developed were there space:—(1) New England transcendentalism was begotten by the writings of Coleridge, Cousin, and Carlyle on the theology of Puritanism as expounded by profound thinkers like Jonathan Edwards. None of its inspirers ever visited America, and, if Emerson visited Coleridge and Carlyle, he professed that he derived little benefit from personal intercourse with either of them. Yet New England transcendentalism is a distinct variety of philosophic thought. (2) Darwin never visited Germany, and few Germans were received at the modest house in Down; yet Darwin's writings initiated a new and fruitful movement in that country to which no bounds can be set. Darwinism developed by Haeckel is, again, a distinct variety.

From these few examples alone we might conclude that "nature abhors self-fertilisation" in civil as in natural history, and that no sociological species, as no biological species, is perpetually self-fertilised. Where a nation, like the Chinese, maintains its vigour intact for centuries of refusal to cross, it owes its tenacity to being one of the most widely migratory peoples on record. Dispersal over a large area may protect a species against its own exclusiveness.

THE CHEMISTRY OF THE STARS.

II.—VARIETIES OF SPECTRA.

By A. Fowler, F.R.A.S.

The first recorded observations of the spectra of the stars and planets were made in 1814 by Fraunhofer, who then discovered the important facts that Venus and Mars had spectra resembling that of the sun, while the spectrum of Sirius was very different. After increasing his previously very small optical equipment—a prism of 60° in front of the telescope of a theodolite—it was found that the spectrum of Castor was like that of Sirius, the spectra of Capella and Pollux similar to the spectrum of sunlight, and the spectrum of Betelgeuse somewhat different. Fraunhofer, in short, recognised that there were at least three varieties of stellar spectra.

It was not until 1859, however, that these observations received the notice to which they were entitled. In that year Kirchhoff published his researches on the origin of dark lines in spectra, and it soon became evident that the methods employed in the analysis of sunlight could be equally applied to the determination of the chemical constituents of the stars. Rutherfurd, Secchi, and Sir William Huggins were most prominent among the earlier workers in this direction, and while the latter observer chiefly concerned himself with the minute analysis of a few stars, the others observed a greater number of stars with a view to their classification into groups. Following up this pioneer work, detailed investigations of the spectra of the stars have been carried on with conspicuous success by Prof. Pickering in America, Sir Norman Lockyer, Sir Wm. Huggins, and Dr. McClean, in England, and Professors Vogel and Scheiner in Germany.

As a general result of the work which has been done, it is found that the great majority of the thousands of stars which have been studied either fall into one of the types recognised by the earlier observers, or may be considered as intermediate between two of the types; that is, the different varieties merge into each other by almost insensible gradations. For this reason it is now generally believed that stars are not fundamentally different in chemical composition, but that the differences in their spectra are mainly due to differences in the physical states which the stars have reached in an evolutionary process.

In classifications of stellar spectra, an attempt is accordingly made to indicate the order in which the various spectra succeed each other in the history of a star, and not merely to put similar stars into the same group. There are some points, however, on which authorities differ, though there is a general agreement in regard to some of the principal types; and it is doubtless because of the divergencies of opinion that the classification suggested by Secchi, with slight additions, is even now the only one which can be considered an universal language of the subject. It is, in fact, still a very convenient classification so far as concerns the observations which can be made visually, though it is hopelessly inadequate to deal with the finer differences of spectra revealed by modern photographic methods. There is one feature of Sir Norman Lockyer's classification which has much to recommend it as a tentative nomenclature for the greater number of groups which must now be separately distinguished. In this, the various groups are no longer denoted by a distinctive number or letter, but by a name derived from that of a typical star, a plan which had been previously adopted in a small way by other writers; thus if a star gives a spectrum like that of Sirius, it is called a *Sirian* star; if like Antares, an *Antarian* star; if like 19 Piscium, a *Piscian* star, and so on. This nomenclature has the advantage of admitting of easy extension as future researches may require, without disturbing any arrangement of numbers or letters.

It is proposed to discuss later the more important varieties of spectra in some detail, but meanwhile it will facilitate matters to take a broad general review of the various types. In the light of our present knowledge, the classification of Secchi may be conveniently extended as follows, retaining his enumeration so far as it goes, and indicating the varieties of each which have been separately named by Lockyer:—

Type O.—Spectra in which the dark lines of hydrogen and helium are of moderate intensity and nearly all other lines relatively feeble.

From their frequent occurrence in the constellation Orion, the stars of this type are often called "Orion stars," but they are by no means confined to that part of the heavens.

"Helium stars" is a name also sometimes applied to stars of this class.

A few stars of this type, such as γ Cassiopeiæ, show bright lines in addition to the dark ones. These are frequently referred to as stars of the "Orion type with bright lines."

Includes the stars classified by Lockyer, according to differences in detail, as *Alnitamian* (so named from ε Orionis), *Crucian* (β Crucis), *Taurian* (ζ Tauri), *Achernian* (α Eridani), *Algolian* and *Rigelian*.

Type I.—Spectra in which the dark lines of hydrogen are very strong and all other lines relatively weak. The weaker lines include both arc and spark lines of various metals.

Includes the groups named by Lockyer *Markabian* (α Pegasi) and *Sirian*. The *Cygnian* (α Cygni) stars may be regarded provisionally as a special variety in which the hydrogen lines are somewhat subdued, while the spark lines of the metals are especially developed.

Type I.-II.—Spectra intermediate between Types I. and II.; the hydrogen lines are of moderate strength, and a great number of metallic lines, both arc and spark, are also conspicuous.

Includes Lockyer's group of *Procyonian* stars. The *Polarian* group, also having numerous dark lines, may be provisionally regarded as a special variety; the hydrogen lines are less intense than in Procyon.

Type II.—Spectra resembling that of the sun, in having a multitude of strong lines corresponding with lines seen in the arc spectra of the metals, the hydrogen lines having lost their predominance. From their resemblance to the sun, the stars of this class are often called stars of the "solar type."

Includes Lockyer's groups of *Aldebarian* and *Arcturian* stars.

Type III.—Spectra with dark flutings, fading towards the red end of the spectrum, and having also many metallic lines. The hydrogen lines are very feeble.

Includes Lockyer's *Antarian* group.

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Type IV.—Spectra with dark flutings, due to carbon, fading towards the blue end of the spectrum. All stars of this type are fainter than 5th magnitude.

Includes Lockyer's *Piscian* group.

Type V.—Spectra consisting chiefly of bright lines, some of which are due to hydrogen and helium, and others are at present of unknown origin. On account of the first examples having been discovered by Messrs. Wolf and Rayet, they are often called "Wolf-Rayet stars."

Stars of types O and I. are white, those of type II. vary from yellowish-white to yellow, and those of types III. and IV. range from yellow to red.

An attempt to illustrate the more common spectral types is made in Fig. 5. The spectra are drawn as they

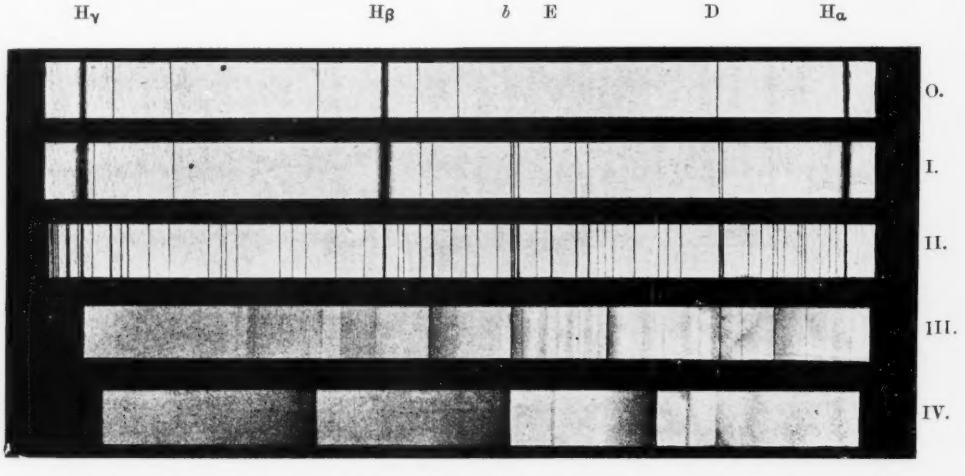

FIG. 5.—The Five principal Types of Spectra. O, γ Orionis; I., Sirius; II., Arcturus; III., α Orionis; IV., 152, Schjellerup.

appear in prismatic spectroscopes, where the blue end is more dispersed than the red. The spectra of the third and fourth type stars are reproductions of drawings made by Dunér, who has made a special study of these stars.

Remembering that Fraunhofer made *discoveries* with a telescope only a little over an inch in aperture, it will be evident that the observation of the general features of the principal varieties of spectra is possible without any great instrumental equipment, though it must be admitted that it requires a considerable amount of patience. Still, a persevering observer will be well rewarded for his trouble, even if his telescope has no greater aperture than three inches, if he provides himself with a suitable spectroscope.

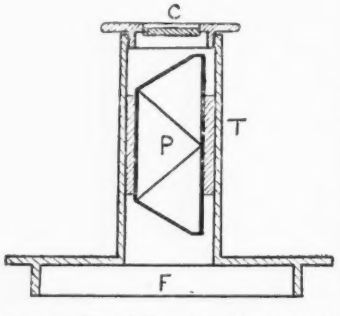

FIG. 6.—The Zöllner Star Spectroscope.

One of the most convenient instruments for viewing the spectra of stars is the Zöllner "ocular" spectroscope, the parts of which are diagrammatically shown in Fig. 6. A small direct-vision prism, P, is inserted in a tube, T, terminating in a flange, F (adapted to fit on the telescopic eyepiece like an ordinary sun-cap), and having a cylindrical lens, C, which comes between the eye and the prism. Suppose that after centering a star in the usual manner in the telescope the spectroscope is added without the cylindrical lens. In place of the ordinary star image a thin line will be seen, red at one end, and passing through all the colours of the spectrum to violet at the other end. Under these conditions the spectrum "lines" are mere dots, and to make them more easily visible it is necessary to broaden the spectrum by introducing the cylindrical lens, so that the dots are spread out into lines. The use of this spectroscope is thus very simple—the star is centred and focussed in the ordinary manner, and then the spectroscope is slipped on the eyepiece, no alteration of focus being required.

Another well-known arrangement is the McClean star spectroscope. Here the cylindrical lens is a concave, and combines the functions of the cylindrical lens with those of the telescopic eyepiece. The cylindrical lens alone, if used as an eyepiece for the telescope, will show a star image as a short line of light, of course without colour, and this is spread out into a spectrum when the prism is added. The procedure with this instrument is first to centre the star in the telescope in the usual way, remove the eyepiece, insert the spectroscope, and push in towards the object-glass until the lines appear properly focussed. When once the focus has been determined it is useful to mark the position of the draw-tube.

Believing that a record of actual experience with small instruments will be useful to many readers of KNOWLEDGE, I have asked my friend, Mr. A. Foote, F.R.A.S., who has devoted much attention to stellar spectra as observed with a 3-inch telescope, to be kind enough to furnish me with a few notes as to what he has been able to observe. In acceding to my request, Mr. Foote writes:—

"I am very glad to supply you with a few selected stars out of a very large list which I have examined with small spectroscopes in my 3-inch telescope. As you are aware, I prefer the Zöllner form of spectroscope, as I found the McClean more difficult to focus. I also found that the McClean did not bring out the solar type stars so well as the Zöllner.

"The stars which give the easiest results to a beginner are those of Type I., in which the hydrogen lines are so prominent. In *Sirius*, the hydrogen lines at F and G (Hβ and H_γ) are easily picked up, and are very broad and distinct. *Vega* is perhaps even a

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NEBULA INDEX CATALOGUE 405 AURIGA.

By ISAAC ROBERTS, D.Sc., F.R.S.

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more typical star of this class, and I think that, on the whole, the two hydrogen lines come out still more distinctly than in the mighty Sirius. Other easy stars of this class are *Altair*, *Castor*, *β Arietis*, *α Ophiuchi*, the stars of the *Plough* (with the exception of *α* and *η*, which are of different types), and *Regulus*. Stars of lesser magnitude, such as *α Coronæ*, are of course more difficult.

"In stars of the second or solar type, the little instruments will be able to show that there are many sub-divisions of the family. The great *Arcturus* shows many lines, but it is not such an easy spectrum as *Aldebaran*, which gives one of the fullest spectra which can be seen with the means at our disposal. In *Pollux* the lines are finer and more difficult for the beginner, while in *Capella* they are more difficult still.

"Intermediate between these classes comes an easy and beautiful spectrum—that of *Procyon*.

"*Betelgeuse* is perhaps the easiest and best example of the third type; just now it is very beautiful, as the star is so bright. *α Herculis* is more delicately beautiful, but of course is a little more troublesome for the beginner, as it is of considerably less magnitude. *Antares* is very fine, but owing to its southern declination is difficult to get free of atmosphere. *δ Virginis* is pretty beyond words, but is not for beginners. *β Pegasi* is easy and typical.

"The possessor of the small instruments should by all means look at *Rigel* and other bright stars of the Orion type, but he must not be disappointed if he sees no lines! neither will he see much in Spica, which is also of this type; nor, I am afraid, in *α Cygni*, which is a standard spectrum in its way.

"He should also look for the bright C line of hydrogen in *γ Cassiopeiæ*; I have not yet seen it myself, but I mean to!

"A man with these small means must not expect to see everything at the first glance. The hand needs to be trained as well as the eye, as there is no driving clock to keep the stars in the field, but after a little experience the observations are of the greatest possible interest."

PHOTOGRAPH OF THE NEBULA ROUND THE STAR DM. NO. 980, ZONE 34°, IN THE CONSTELLATION AURIGA.

By Isaac Roberts, D.Sc., F.R.S.

The photograph annexed delineates the region in the sky between R.A. 5h. 7m. 56s. and R.A. 5h. 11m. 53s., and in Declination between 33° 44′·2 and 34° 48′·0 north. The area, therefore, is 3m. 57s. in extent from *following* to *preceding*, and 1° 3′·8 from north to south. Scale—one millimètre to 15·5 seconds of arc.

Co-ordinates of the fiducial stars marked with dots for the epoch 1900:—

Star (.) DM. No. 978. Zone +34° R.A. 5h. 9m. 18s. Dec. 34° 18′·8. Mag. 7·8.
Star (..) DM. No. 985. Zone +34° R.A. 5h. 10m. 58s. Dec. 34° 8′·2. Mag. 9·2.

The description given of this nebula in Dr. Dreyer's *Index Catalogue*, No. 405, with the names of Schaeberle and Max Wolf, is as follows:—Star 6·7 mag., with pretty bright, very large nebula.

The photograph was taken with the 20-inch reflector, and exposure of the plate during ninety minutes on the 14th January, 1902, and the star referred to in the paragraph above is DM. No. 980, zone 34°. It is involved in the denser part of the nebulosity on the photo-print annexed, at 30 millimètres *south following* the fiducial star (.), but on the negative its image is very clearly shown in the midst of the nebulosity. This condition of obscuration is unavoidable on all copies made from the original negatives, when there is both dense and very faint nebulosity on the same plate, because the faintest stars, the condensations, and structural details in many of the nebulæ, though they are visible on the negatives, cannot be reproduced on copies made from them without sacrificing the relative proportions of the density of the nebulosity as a whole, and thus causing a less accurate perception of the nebula. If we reduce the density of parts of the nebulosity, when making a copy, for the purpose of showing more of the involved details of the structure, the reader should be informed of the fact so that he may not be misled into making erroneous inferences when comparing photographs with each other.

On referring to the annexed photograph it will be seen that the nebula is apparently placed in a crowded field of bright and faint stars in the Milky Way, but we are not warranted in assuming that the normal stars we see scattered over its surface are involved in the nebulosity. There are many star-like condensations in the nebula that doubtless are now undergoing the process of development into stars of the normal type, which, after a lapse of millions of years, may form a cluster of stars such as eye observations and photographs have revealed to us as existing in various parts of space.

The nebula measures about 33 minutes of arc from north to south, and 27 minutes from *following* to *preceding* on the negative. There are extensions of very faint nebulosity on the *preceding* side, beyond the limit of the annexed photograph, but they are too faint for copying. If these were included the nebula would extend to 75 minutes of arc in *north following* to *south preceding* direction, and 54 minutes in *south following* to *north preceding*. This faint nebulosity is of a flocculent character, with broad tortuous rifts in it which trend in diverse directions.

The nebula is one of a class of which we now possess many photographic delineations on a scale sufficiently large for measurements and for scientific investigations, which work we are now and for some time past have been engaged upon.

MAN'S PLACE IN THE UNIVERSE.*

By E. Walter Maunder, F.R.A.S.

Perhaps the greatest drawback under which Science—not one science alone but each and all of the sciences in turn—labours at the present time is the impatience of the general public to receive precise, definite, and striking results. Thus, for example, most popular scientific lecturers find that their audiences look to them to lead up to some clear, crystallised conclusion. It demands some courage, and great skill, to press home upon a popular audience the truth that just in proportion to the advance of our knowledge so is the increase in the number of the problems which are presented to us for solution. The horizon recedes as we advance, and, more than that, it widens at the same time.

A striking example of the eagerness with which the conjecture of a scientific man will be caught up, if only it be sufficiently definite and far-reaching, is afforded by Mädler's celebrated suggestion that the sun with its attendant planets might be travelling in a gigantic orbit of which the focus might be within the group of the Pleiades. In how many thousands of essays, lectures, books, and sermons the statement has appeared that science has proved that the centre of attraction of the universe is located in Alcyone, the chief of the Pleiads, it would be useless to guess. Contradicted a thousand times, the legend seems to have lost none of its pristine vigour. Give a fable a yard's start, and Truth appears to be unable to overtake it in less than a century.

We greatly fear that just such another myth has been started on its career, and by one of the most highly and

* "Man's Place in the Universe, as indicated by the New Astronomy," by Alfred Russel Wallace, D.C.L., F.R.S. *Fortnightly Review*, March, 1903.

most justly honoured of living men of science. The *Fortnightly Review* for March, 1903, opens with an article, at once striking and attractive, on "Man's Place in the Universe, as indicated by the New Astronomy," by Alfred Russel Wallace, D.C.L., F.R.S. The article leads up to a theological application which it does not lie within our province here to discuss; it is the astronomical basis of the article alone with which we are concerned.

Dr. Wallace's first thesis is that the stellar universe is finite in extent and the stars finite in number. His next point is that the proper motions of stars furnish the best indication of their distances. Then he argues that the solar system is about equally distant from all parts of the Milky Way, and exactly in its plane. Then that the sun is one of the central orbs of a globular star cluster, and that this star cluster occupies a nearly exactly central position in the exact plane of the Milky Way. "Our sun is thus shown to occupy a position very near to, if not actually at the centre of the whole visible universe, and therefore in all probability in the *centre* of the *whole material universe*."

This completes the first part of Dr. Wallace's enquiry; the second part deals with the earth's position in the solar system as regards its adaptability for organic life. Here Dr. Wallace leaves strictly astronomical questions and is on his own ground. His point is that the conditions for the development of organic life are far more stringent than has been generally recognised. The surface temperature of the planet must remain stable within a very limited range, not for hundreds or thousands of years, but for millions, perhaps for hundreds of millions. The chief favourable conditions which in their combination appear to have rendered the development of a complex system of organic life possible on our earth are, its distance from the sun securing the equability of temperature just mentioned; an atmosphere of sufficient density; broad and deep oceans, stirred into tides by the action of a large satellite; and the presence of deserts and volcanoes for the distribution of atmospheric dust. The stringency of these conditions appears to indicate that our earth is the only home of organic life within the solar system, and Dr. Wallace considers that suns near the confines of the stellar universe cannot have systems sufficiently stable for their planets to fulfil these conditions there. In his view, therefore, the position of the solar system in the centre of the material universe renders it probable that here, and here alone, has organic life reached its full development.

It will be seen that the entire argument falls to the ground if the first point, the demonstration that our universe is finite, is not complete. As Dr. Wallace himself remarks: "Infinite space has been well defined as a circle, or rather a sphere whose centre is everywhere and circumference nowhere," and unless the material universe can be proved to be finite, we certainly cannot prove that any particular body occupies its centre. Dr. Wallace's argument is, first, that the telescopes of greatest size have failed to reveal to us fainter stars in anything like the same proportion which smaller telescopes had done; as if we were looking right through the stellar universe, and out into the blackness of space beyond. This is partly accounted for by the fact that the increase in aperture of a refractor is necessarily accompanied by an increase in the absorption of its object-glass, and we are approaching the limit where the gain and loss will be balanced. So too with the photographic plate. For medium luminosities it is perfectly true that an increase of exposure will compensate for inferiority of light in a strictly commensurable degree; but the correspondence ceases to hold good when we are dealing with very faint lights.

Dr. Wallace's next argument is an extraordinary one. He tells us, and quotes Prof. Newcomb* in his support, that were the stars infinite in number, then we should receive an infinite amount of light from them. A reference to what Prof. Newcomb actually has written shows that Dr. Wallace has omitted two important limitations which Prof. Newcomb attaches to this conclusion. It rests upon the hypotheses "that light is never lost in its passage to any distance however great," and "that every region of space of some great but finite extent is, on the average, occupied by at least one star." In short, Prof. Newcomb's demonstration rests on the two conditions that light must come through space to us without any loss, and that the stellar universe must, on the whole, be uniform in constitution; it must not be structured. We know that neither of these conditions holds good. As there are bright bodies in space, so are there dark bodies. If the first be infinite in number, so must also be the second; we may almost say that the infinity of the second must be of a higher order. As Sir Robert Ball recently put it, "the dark stars are incomparably more numerous than those that we can see . . . and to attempt to number the stars of the universe by those whose transitory brightness we can perceive would be like estimating the number of horseshoes in England by those which are red hot." The same line of argument which would infer that from an infinity of bright suns the background of the sky should shine as the sun at noonday, will lead yet more forcibly to the conclusion, when the dark stars are the basis of the argument, that we are shut in by a veil which no light from an infinite distance can pierce. On the second point, that of structure, we need only the evidence of our eyes. The existence of the Milky Way is proof that our stellar system has a strongly marked form. There is no approach to uniformity of the stars as to direction, why should we assume that there is in distance? But Dr. Wallace does not see that these two conditions are vital. He writes: "Even if we make an ample allowance for the stoppage of light by intervening dark bodies, or by cosmic dust, or by imperfect transparency of the ether, we should at least receive quite as much light from them as the sun gives us at noonday," forgetful that the entire argument depends upon the exclusion of these three causes of absorption.

The attempted demonstration of the finite nature of the universe thus breaks down entirely; it is based upon a careless reading of Prof. Newcomb's book. In his next point Dr. Wallace again rests upon Prof. Newcomb, whilst again ignoring his deductions. He quotes:—"If we should blot out from the sky all the stars having no proper motion large enough to be detected we should find remaining stars of all magnitudes, but they would be scattered almost uniformly over the sky, and show no tendency towards the Milky Way." Prof. Newcomb's words are actually somewhat different. He writes, "show little or no tendency to crowd towards the Galaxy, unless, perhaps, in the region near 19 hrs. of R.A. From this, again, it follows that the stars belonging to the Galaxy lie farther away than those whose proper motions can be detected." This conclusion of Prof. Newcomb's cannot be disputed, but Dr. Wallace substitutes for it another, viz.: that stars with measured proper motions constitute a globular mass, and that we must be situated very near indeed to the centre of this solar cluster.

The points upon which Dr. Wallace lays stress as to the Galaxy, namely, that the sun is situated in its central plane, and nearly centrally with regard to it, are indeed

* "The Stars: A Study of the Universe." By Prof. Simon Newcomb.

matters of fact. But, on the one hand, so far from his having led the way in pointing out these facts, they have been fully considered by every astronomer who has treated of the Galaxy at all; and, on the other hand, he gives to the two facts a greater precision than he is warranted in doing. The Galaxy marks out roughly a great circle in the sky; it is far too irregular an object for anyone to be able to declare that its axis lies precisely along a great circle. But it is exceedingly convenient to treat it as if it did, and no error can arise from such a convention except when an argument like Dr. Wallace's is seriously based upon it. But with regard to our sun being placed in its centre, the estimate of the distance from us of the mean mass of the Milky Way is roughly three hundred light-years; a "light-year" being the distance which it takes light a year to traverse, nearly six millions of millions of miles. Our distance from Alpha Centauri is a little over four light-years, so that we have no right to say that we are nearer the centre than this twin sun of ours; nor indeed would it be safe to assert it of any of the stars whose parallax can be considered really well-determined. From the nature of the case, a distance of over thirty light-years involves a parallax too small for really satisfactory handling, and yet makes but an inconsiderable fraction of the diameter of the ring of the Milky Way.

More than that, our sun is itself travelling at a pace sufficient to bridge the distance to Alpha Centauri in sixty-five thousand years, a mere moment in our world's complete life-history. If this pace has been maintained in a straight line, five million years ago we were deep in the actual stream of the Milky Way; five million years hence we shall have completely crossed the gulf which it encircles, and again be a member of one of its constituent groups, but on the opposite side. And ten million years are regarded by geologists and biologists as but "a trifle on account" to meet their demands upon the bank of Time.

The paragraphs on "The Earth as Adapted for Life" are rather for biologists to criticise than for astronomers, but the conclusion of the paper contains several statements which almost lead us to doubt whether we have not been mistaken in supposing the article to be a serious one, and whether it was not intended as an elaborate skit on astronomical cosmogonies. How else can we regard the statement that "we can actually *see* beyond the outer boundaries" of the material universe, "a limited universe of matter and ether." To see beyond the luminiferous ether reminds one of the inventor who discovered a universal solvent, but did not know of what to make the bottle in which to hold it, so that the precious liquid was all lost. Dr. Wallace compares the stars of the Milky Way to the molecules of a gas, and suggests that "a certain proportion of them would continually escape from the attractive power of their neighbours, and wandering into outer space soon become dead and cold and lost for ever to the universe." The process, he not obscurely intimates, will be continued indefinitely, until this earth of ours, from being the centre of the universe, will become the centre of a space from which the universe has all departed. He thus offers to our poor planet only the cold comfort which Polyphemus tendered to Odysseus, that he should be eaten last. Dr. Wallace further intimates that "at any considerable distance beyond the central portion of the universe gravitation would vary in intensity in different directions," and gravely suggests that this variation may possibly be detected by means of the motions of remote binary stars.

To sum up, the little in Dr. Wallace's paper which can fairly be said to be demonstrated fact is anything but new, and that which is new, whether true or not, is as yet but speculation. His conclusions are, at the best, premature, and lie in a region which, from its very nature, must probably always be outside the bounds of our knowledge. The Milky Way, which forms the chief portion of the structure of that sidereal system in which we are placed, no doubt is finite in extent, and we can make certain statements with regard to it. But we are not yet in a position to say that all of the objects revealed to us by the telescope are included in that system; nor can we legitimately assert that what is apparently true of such of it as we can see is absolutely true of the entire material universe. Dr. Wallace's underlying error is, indeed, that he has reasoned from the area which we can embrace with our limited perceptions to the Infinite beyond our mental or intellectual grasp. We are on the earth, and can only reason, only guess, from our earthly experience of the laws, of the materials, of the conditions elsewhere. Our eyes have limited powers of vision, our mental grasp is confined, our days are but few on the earth, and our experience small; all these boundaries limit for us the universe, however vast it may actually be, and inevitably tend to make our view-point seem to be the centre of our horizon.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE VISIBILITY OF THE CRESCENT OF VENUS.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—With regard to this discussion, perhaps I may be allowed to quote from Sayce, in "Fresh Light from Ancient Monuments," 4th edition, page 120, where he says that "Ahaz had introduced into Judah the study of astronomy, for which the Babylonians were renowned, and had set up a gnomon or sundial in the palace court (2 Kings, xx. 11). It is possible that some of the astronomical literature of Babylonia, which has been recovered from the cuneiform tablets now in the British Museum, was introduced at the same time, with its multitudinous observations and predictions of eclipses, its notices of the appearance of comets, of the movements of the planets and fixed stars, *of the phases of Venus*, and even of spots on the sun. It is also possible that the Assyrian calendar and the Assyrian names of the months now first became familiar to the Jews."

I have also seen it stated that Layard found at Nineveh a rock crystal lens, which, however, in Dr. Brewster's opinion, could only have served as a burning glass.

4, East Broughton Place, Edinburgh. W. T. Mackie.

19th February, 1903.

[The oldest Babylonian *calculations* of the moon and the planets are to my knowledge the Inscriptions of the eighth year of Cambyses, which I had published in the "Babylonian Inscriptions of Cambyses," cp. "Un annuaire astronomique Babylonien traduit en partie en Grec par Ptolémée," par M. J. Oppert, "Journal Asiatique," 1890. That system of calculation had been variously improved by different astronomical schools during the reign of the Achaemenian Persian kings, the Seleucides and the Arsacides, down to the first century B.C. These calculations are mainly cyclical:—The Saros period for the Moon; for Jupiter a period of 83 years, or of 83 ± 12 years; for Venus a period of eight years; for Mercury a period of 46 years; for Saturn 59 years, and for Mars a period of 32 or 47 years,

and of 47 ± 15, and of $47 + 32$ years. The greater number of inscriptions refer to observations made in order to verify and correct these periods. There are older observations of the moon known from Assyria, but chiefly made for the purpose of astrology and festival arrangements. Up to date there is no inscription known to me where the "phases of Venus" would be given; the observations are about Venus as the evening or morning star. In a later period there were elaborate systems of calculating the heliacal rising and setting of Venus and Mercury and the other planets, and the author quoted by Mr. Mackie probably meant these heliacal risings and settings of Venus by the expression "phases of Venus." Spots on the sun are never mentioned in any inscriptions, unless the author translates the word "cloud" by "spot," or has misunderstood the expression for an eclipse. The crystal lens, found at Nineveh by Sir Austen H. Layard, now preserved in the British Museum, is very roughly made, and could, evidently, not be used for any observation. The names of the Jewish months seem rather to be derived from an earlier intercourse with Babylon than from Assyria, and after the Babylonian Exile the Babylonian names were in common use amongst the Jews.—J. N. Strassmaier, S.J.]

THE CROSS OF S. SOPHIA.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—In the first of M. Antoniadi's interesting papers on S. Sophia (Knowledge, for February, 1903, p. 30), he comes to the conclusion that a large cross stood outside the dome, similar to that on S. Paul's in London; but he brings no evidence in support of his contention except the passage which he quotes from Paulus Silentiarius, a passage which has been differently interpreted by very competent persons. I should like to ask if M. Antoniadi can quote any other instance in Greek literature where ἔγραφε is used for anything except a design on the flat, whether by writing or painting, or possibly mosaic. The use of ἔγραφε was certainly not caused by poetical necessities, as ἔπλασε or ἔκτισε fits the hexameter equally well. But the interpretation of the Silentiary's poem does not depend here upon the single word; the whole context of the passage refers to the magnificent appearance of the dome *from the inside*. The poet compares the dome to the vault of heaven, an idea that would never occur to anyone who was thinking of the appearance of the outside. In the age of Justinian the heavens were thought of as a great spherical vault seen from below, and the top, the κορυφή, is the zenith. At the zenith of Justinian's dome, on the inside therefore, above every object in sight, above the highest point of the enclosed space, the great cross was drawn, brooding over the worshippers.

As to the cross being the "protector of the city," surely the Byzantines were not so foolish as to suppose that the position of the cross made any difference to its supernatural virtue; and if any particular cross was to be regarded as the palladium of Constantinople, it would be not Justinian's architectural ornaments, but the True Cross which was kept inside the church and exposed there three days in the year for the veneration of the faithful. But, doubtless, ἐρυσίπτολις merely expresses the general belief that the symbol of the Christian religion everywhere protected the city of Constantine.

My regretted friend Harold Swainson is not alive to defend his translation of the Silentiary's poem. I have therefore written these few lines to express the opinion that if M. Antoniadi is to convince us that Justinian's Church of S. Sophia had a cross on the outside of the dome he will need to bring forward some other evidence than the passage he has quoted from Paulus.

Elterholm, Cambridge. F. C. Burkitt.

[In wishing to deprive mediæval Greek churches of their outer cross, Mr. Burkitt is assuming a gravely artificial position, whose defence is very difficult, if not altogether impossible. The "other evidence" he is asking for is now brought forth in my third paper, printed in the present number of Knowledge, where I show that, in opposition to Mr. Burkitt's assertion that the great cross was drawn inside, "brooding over the worshippers," the poet Paulus describes at the very place of this would-be cross, the image of Christ in a mosaic circle. And we know that to paint Christ at the crown of the cupola, inside, was a recommendation of the Greek "Painter's Manual." We thus reach the irrefutable general inference: As there was a cross somewhere about the dome of St. Sophia, and as it was not inside, it must necessarily have been on the outside.

This focusses matters, and justifies the sense of *figured*, which I gave to ἔγραφε. The attempt to confine the meaning of that verb to writing and painting suggests some lack of knowledge of Greek, as, in the first place, γράφειν meant *to scratch, to incise, to carve*, all of which meanings imply, of course, action in a solid. And, in choosing the word ἔγραφε, the poet probably wanted to say that the cross was "artfully carved out" of metal. The fact that the context interesting us describes the interior of the dome is utilized by Mr. Burkitt as a corroboration of his views. But a closer examination ought to show him that it really militates against them, for, approaching as he does, the crown of the dome on the inside, the poet thought he ought to say a word on the outer cross, and actually does this by selecting the proper adverb, ὑπέρ, *above, beyond*, implying the change of plane from inside to outside.

Mr. Burkitt, further, does not see that, in placing his mosaic cross "above the highest point of the enclosed space," he locates it either in the thickness of the brick vaulting, or even draws it on the outside—both of which conclusions are, of course, unlikely.

Mr. Burkitt's letter is the product of an error in his authority's translation. The poet places his cross ὑπὲρ δὲ ἀκροτάτης κορυφῆς, literally, "but above the most extreme summit," whereas th late Mr. Swainson inadvertently translated "and at the highest point," giving to the expression ὑπὲρ δέ, *but above*, the meaning *and at*, which, I am afraid, it never had.

1903, March 12. E. M. Antoniadi.]

British Ornithological Notes.

Conducted by Harry F. Witherby, F.Z.S., M.B.O.U.

The Migrations of the Lapwing.—The following is a brief summary of Mr. W. Eagle Clarke's account of the migratory movements of the Lapwing:—

Generally it may be said that the movements of this bird largely escape notice. Lapwings do not often approach the light-stations. They do not seem to emigrate from the British Islands in autumn to any extent, but they come to winter with us from the Continent. The most marked movements of the Lapwing are connected with the weather, and are mainly confined to passages from the north of Great Britain southwards, and from inland to the coast in winter, and *vice versa* in spring.

British Summer and Autumn Movements. — Commencing exceptionally in July, but generally in August, emigration from the north of Scotland and the high breeding grounds goes on gradually until the beginning of November, when the birds are mostly to be found in

the south of England, or in sheltered lowlands near the coast. During October and November too there is a passage of Lapwings from Northern Britain to Ireland.

Autumn Immigration from North-Western Europe.—Arrivals of Lapwings from Scandinavia occur throughout October and the early part of November, but in no great numbers.

Autumn Immigration from the East.—The records, although meagre, are sufficient to leave little doubt that immigrants from the Continent—occasionally in considerable numbers—arrive on our east coast by a direct passage across the southern waters of the North Sea. This immigration is renewed during severe winters on the Continent.

Autumn Passage of Immigrants.—Lapwings, it seems, do not use our coasts—as so many other birds do—as a mere highway on their passage north and south to other countries.

Autumn Emigration from Britain. — Our native Lapwings and the autumnal visitors from the Continent seem loth to quit our shores. No Lapwings have been detected crossing the Channel before November, when the approach of winter constrains some of them to seek more genial climes.

Winter Movements and Emigration.—These are controlled by, and vary with, the climatic conditions of the season, and their extent is proportional to its severity. Heavy snow and severe frost cause great movements southwards along the coast and overland. Should such conditions extend to the South of England, much emigration is embarked upon for the shores of France. Devon, Cornwall, and the Scilly Isles, as well as Ireland, are also much resorted to during severe frosts and snowstorms. It is when thus retreating before adverse conditions that the movements of the Lapwing become pronounced and widespread, and, in this respect, contrast markedly with the other migrations of this species. On these occasions, too, the bird chiefly approaches the light-stations. Comparatively few perish by starvation.

Spring Movements from British Winter to Summer Haunts.—Occasionally earlier, but usually towards the end of February and early in March, the Lapwings gradually return to their breeding haunts in Britain.

Spring Immigration from Southern Europe. — The Lapwings that have left England for the south appear to return across the Channel towards the end of March.

Spring Passage Northward and Emigration to Northern Europe.—During March and until mid-April the return migration northward of the Lapwings proceeds in a somewhat leisurely fashion. The emigrants for North-west Europe mainly move along the east coast. Those that have wintered in Ireland generally depart from the north-east coast and proceed in various directions towards Scotland. No return passage in spring of Lapwings across the south of the North Sea to Central Europe has been noticed, but as these birds move by night, and are seldom attracted by the lights, there is great difficulty in observing small movements.

The Status of the Goldfinch in Britain (Zoologist, January, 1903, pp. 23-26).—Mr. J. A. Harvie-Brown here gives brief extracts from various authors to show the status of the Goldfinch in many counties. It is proposed to bring the information up to date, and to complete it as far as possible with the co-operation of different observers.

Bulwer's Petrel in Sussex.— At the February meeting of the British Ornithologists' Club, Mr. J. L. Bonhote recorded that a specimen of this bird was picked up dead near Beachy Head, on February 3rd last. Bulwer's Petrel breeds in the Canaries and Madeiras, as well as in some islands in the Pacific. It has been known to occur only once before in Great Britain, viz., in Yorkshire in 1837.

All contributions to the column, either in the way of notes or photographs, should be forwarded to Harry F. Witherby, *at the Office of* Knowledge, 326, *High Holborn, London.*

Notes.

Astronomical.—A variable star, with a period shorter than that of any variable previously known, has been lately discovered in the course of the photometric work at Potsdam. The period is 4h. 0m. 13s., and the range of variation from mag. 7·9 to 8·6. Changes of magnitude go on continuously throughout the period, so that the variability is not of the simple Algol type. The star is B.D.+ 56° No. 1400, R.A. 9h. 36m. 44s., Decl.+ 56° 24′·6.

In a discussion of his photographs of the spectrum of the chromosphere taken during the eclipse of 1900, Mr. Evershed confirms the conclusion, arrived at previously by Sir Norman Lockyer, that the lines of a metal which are exceptionally strong are in most cases lines which are enhanced in the spark spectrum. In explanation of the predominances of these lines throughout the whole depth of the chromosphere, and their relative absence from the Fraunhofer spectrum, it is suggested that the entire chromosphere consists of small eruptions of the nature of metallic prominences or jets of highly-heated gases, the ascending hot gases giving the predominant features to the flash spectrum, while the Fraunhofer spectrum represents the absorption of the cooler descending gases only.

Dr. Chree, of the National Physical Laboratory, finds that the equinoxes are the seasons at which the amplitude of the diurnal inequality of terrestrial magnetism, when considered absolutely, is most dependent upon sunspot frequency; and that winter is the season when sunspot frequency is most influential relatively to the total range.

Sir Norman and Dr. Lockyer find from a discussion of prominence observations that the variations of the general terrestrial magnetic phenomena synchronise with the occurrence of prominences about the solar equator (the periodicity of which appears to agree very closely with that of the spots), while the "great" magnetic disturbances accompany the outburst of prominences in the polar regions of the sun. This may explain why magnetic storms sometimes occur when no large spot is visible.—A. F.

Botanical.—One of the most remarkable among amphicarpous plants is *Cardamine chenopodifolia,* which has recently been the subject of a paper by Dr. E. P. Wright in *Notes from the Botanical School of Trinity College, Dublin.* This interesting Crucifer is a native of various parts of South America, from Brazil to Argentina and the Island of Juan Fernandez. It produces an aerial raceme of small flowers, which are succeeded by seed-pods similar to those of the British *C. impatiens.* They are usually many-seeded and dehisce elastically, scattering the seeds to some distance. But in addition to the aerial flowers and fruits, others are produced at the base of the plant. The flowers are cleistogamous, extremely minute, without petals, and are borne separately at the tip of subterranean peduncles. The fruit is short and thick, two-celled, and contains one large seed in each cell. This is probably the only amphicarpous Crucifer, but at least two other plants of the order are known which mature their fruit underground, namely, *Morisia hypogæa,* a native of Corsica and Sardinia, and *Geococcus pusillus,* a miniature plant from Western Australia. The former grows in the Rock Garden at Kew. The fruits in both these develop much in the same way as those of the Earth-nut, *Arachis hypogæa.* Amphicarpous plants are found in various natural orders, some particularly interesting ones being discussed in a paper by Dr. Lindman in the *Öfversigt K. Vet.-Akad. Förhandl.,* Stockholm, for 1900.

Sir J. D. Hooker's biography of his father, Sir W. J. Hooker, appeared in the December number of the *Annals of Botany,* and is worth perusal by the general reader as

well as by those specially interested in botanical science. The history of this remarkable man intimately concerns the Royal Botanic Gardens, Kew, of which he was director from 1841 to 1865, previously having been Professor of Botany in the University of Glasgow. The extinction of Kew as a botanical establishment was seriously considered at the close of Mr. Aiton's term of office, but narrowly escaping such a fate, the gardens soon rose, through Sir William Hooker's directing energy, to the foremost position among the botanical institutions of the world. The author of many splendid works, his connection with the *Botanical Magazine* is particularly interesting. This famous serial came into existence in 1787, two years after the birth of Sir William Hooker, was continued throughout his long life, which terminated in 1865, bearing for years on its title-pages his name as editor, and in many cases the plates with his name as artist, and is existing still, controlled by another Hooker, the author of this entertaining biography.—S. A. S.

Entomological.—Conspicuous in Prof. J. W. Gregory's book on the "Great Rift Valley," is a coloured frontispiece representing the protective resemblance of certain homopterous insects to a flower-spike. The insects are shown grouped on an upright stem, small green individuals above representing unopened buds, and larger red specimens below looking like blossoms. In a recent paper in the *Trans. Entom. Society* (1903, pp. 695-698, pls. 26-27), Mr. S. L. Hinde, who has studied the habits of these insects in East Africa, states that the green individuals are as large as the red, that he has never observed them on vertical shoots, but always on horizontal branches, and that the red and green forms occur mixed together. Nevertheless, the whole effect is strikingly like the inflorescence of a leguminous plant common in the district. The larvæ, which are protected by long white waxy threads, do occur in companies on vertical shoots, and present a remarkable appearance. The insect has been identified as *Flata nigrocincta*, Walker.—G. H. C.

Zoological.—In the *Annals and Magazine of Natural History* for December, Mr. O. Thomas describes a new mole (*Talpa romana*) from the neighbourhood of Rome. This species differs from both the common mole and the South European Savi's mole (*T. cæca*) by the much larger teeth, as well as by certain peculiarities in the skull. Savi's mole, it may be remarked, differs from the common species in having a membrane of the eyes, and being therefore truly blind. It is decidedly remarkable that such a distinct form should so long have escaped the notice of naturalists. A wood-mouse collected by Mr. H. F. Witherby, at an elevation of over 5000 feet, near Sheoul, in the Fars district of Persia, has been described by Mr. Thomas in the same issue as a new race, under the name of *Mus sylvaticus witherbyi*. It is characterized by the pure white under-surface, and the small size of the teeth.

The full text of Dr. W. G. Ridewood's valuable memoir on the structure of the gills of the lamellibranch molluscs, the abstract of which was noticed in these columns when it appeared in the *Proceedings* of the Royal Society, has recently been issued in the *Philosophical Transactions*.

Much difference of opinion obtains as to the mode in which the more complicated cheek-teeth have been evolved from teeth of a simpler type. By some authorities it is considered probable that the primitive type was a tooth with three cusps on the crown arranged in the form of a triangle (tritubercular type). Others, on the contrary, favour the idea that complex teeth have been developed by the fusion of two or more teeth of a simple conical type. This view, with certain limitations, receives support in an illustrated article by Dr. H. W. M. Tims, published in the January number of the *Journal of Anatomy and Physiology*.

Many persons have probably been puzzled to account for the circumstance that while the ancestral wild cavies are uniformly greyish coloured animals, the domesticated guinea-pig is usually marked with patches of black, orange, and white. The explanation is, however, not far to seek. As the result of hybridisation, what is known as the dissociation of colours frequently takes place. For instance, hybrid mice may be either black or sandy coloured. The black breed is due to the elimination (probably by crossing with an albino) of the rufous element in the colouring of the typical grey coat; while, conversely, sandy or fawn-coloured mice are the result of the elimination of the black constituent of the compound colour. The various distinct colours, or patches of colour, in the guinea-pig have doubtless originated in a similar manner; that is to say, by the breaking-up of the composite colour of the coat of the wild guinea-pig owing to a cross with an albino subject. Those desirous of further information on this subject, and likewise on the fact that hybrids produce offspring of which some resemble one of their grandparents and some the other, should consult an article on Mendel's law of heredity, recently published by the American Academy of Arts and Sciences.

According to the view of Dr. Scharff, as expressed in a paper recently published in the Royal Irish Academy's *Proceedings*, the "Atlantis" of Plato was a reality and not a myth; Madeira and the Azores having been connected by land with the European and African continents so late as the early portion of the human period. This connection was, however, but the last phase of a great Atlantic continent, which the author believes at an earlier epoch to have extended from Morocco (which was then connected with Portugal) to South America, reaching at least as far south as St Helena. The evidence in favour of this former extensive land connection has been drawn from a careful survey of the whole fauna of the Atlantic islands, which displays marked affinities with that of the Mediterranean countries on the one hand and that of South America on the other. That a land connection between Africa and South America existed at a relatively remote geological epoch is now generally admitted; but stronger evidence will, we think, be required before the theory that the Azores were in connection with Portugal during the human period is accepted. One of the author's arguments is based on the circumstance that so far back as 1385 two of these islands were named from their being inhabited respectively by rabbits and goats, at a time when there were no human denizens of the group. Hence, it is urged, these animals were indigenous, and not, as generally supposed, introduced.

Naturalists will read with interest a paper by Mr. E. T. Newton, in the last number of the Geological Society's *Journal*, describing remains of the elk recently discovered in the Thames valley. The author alludes in some detail to previous finds of elk-remains in this country.

The total result of last year's whaling and sealing by British vessels, according to Mr. Southwell's annual report in the *Zoologist*, was 12 right whales, 652 white whales, 118 walrus, 1984 seals, and 168 bears. Apart from hides, these yielded 212 tuns of oil, worth £22 10s. per tun, and 187 cwt. of whalebone, which now sells at £2500 per ton. Some years ago the price of whalebone reached £2800 per ton; the reduction is probably due to the use of strips of horn for many purposes where whalebone was formerly employed, since the supply of the latter article has certainly not increased.

The ideas generally held with regard to some of the habits of the common mole have been to a considerable extent revolutionized by observations made by Mr. L. E. Adams in Staffordshire, the results of which appear in a recent issue of the *Memoirs* of the Manchester Literary and Philosophical Society. The author shows that the tunnels in the "fortress" or nest-hillock are in nowise constructed on a definite plan with a view to the escape of their owner when danger threatens. He even finds that there is an error with regard to such a simple matter as the number of teats possessed by the female mole. The moral of all this is that we must take nothing on trust in zoological matters.

Zoologists, geologists, and geographers should alike find much to interest them in an essay by Mr. F. W. Harmer on the history of the changes which have taken place in East Anglia during the latter part of the Tertiary period. The essay will be found in the *Proceedings* of the Geologists' Association for 1902.

Some very pertinent remarks on the subject of labels in museums are made by Mr. F. A. Bather in the *Museums' Journal*. After mentioning the advisability of putting popular names on the labels of a large number of specimens, and certain difficulties connected with determining what names to select, the author alludes to the practice which obtains in some museums of adding an abbreviation of the name of the writer responsible for the scientific species-name. If authors' names are given at all, they should be given, Mr. Bather urges, at full length, as otherwise they are absolutely unintelligible to the general public. But are they necessary at all?—he asks; we think not. It may be added that the conventional signs for male and female appended to the names of animals in the Zoological Gardens, Regent's Park, afford another example of the use of abbreviations unintelligible to the public.

Notices of Books.

"In the Andamans and Nicobars: the Narrative of a Cruise in the Schooner 'Terrapin,' with Notices of the Islands, their Fauna, Ethnology, etc." By C. B. Kloss. (John Murray.) Pp. xvi. + 373. Illustrated. Price 21s. net.—Mr. Kloss had the good fortune to accompany the energetic and successful American collector, Dr. W. L. Abbott, in a cruise to the Andamans and Nicobars, undertaken for the purpose of obtaining specimens of their mammals and birds. And it must be acknowledged that, by the production of the volume before us, he has taken full advantage of the opportunities thus afforded him of adding considerably to our information with regard to these interesting islands and their inhabitants. In the case of the Andamans, the author confesses indeed that Mr. Marr's well-known volume on the aborigines has left comparatively little for other observers to record with regard to the anthropology and ethnology of these islands. But in the Nicobars the state of affairs is very different, and Mr. Kloss urges that much ethnological work still remains to be done, and that the time is short during which it will be possible to do this effectively, since the natives are daily changing their primitive customs and habits. A valuable feature of the work before us is to be found in the numerous portraits of Andamanese and Nicobarese with which it is illustrated. Mr. Kloss divides his work into two parts, namely, a narrative of the cruise, and a dissertation on the human and other inhabitants of the islands. These two groups of islands present the peculiarity that whereas the Andamans are inhabited by a negro-like (negrito) race, which is perhaps one of the most primitive types now left on the earth, the Nicobars are populated by tribes belonging to the great Malay stock. The most primitive of the natives of the Nicobars are undoubtedly the Shom-Pen of the interior of Great Nicobar, who appear to be remnants of the aborigines more or less crossed with foreign (perhaps Dravidian) blood. The coast natives of Great Nicobar, as well as the inhabitants of the other islands, are, on the other hand, a later importation, and appear to have originated from a mixture of the aborigines with Malays and Chinese. Mr. Kloss lays great stress on the difference between the Andaman-Nicobar mammals and those of the mainland, commenting on the great preponderance of bats and rodents. This difference, he thinks, indicates that these islands were detached from the mainland before the latter received its present fauna; and he is further of opinion that the Andamanese and Shom-Pen may themselves have introduced some of the mammals, whose differences from their relatives of the mainland may have developed within the period of human occupation. The volume is of the highest interest, both as a record of a delightful trip, and as a mine of information to the zoologist, the anthropologist, and the ethnologist.

"Mont Pelée and the Tragedy of Martinique." By Angelo Heilprin. (Lippincott.) 15s. net. Illustrated.—Professor Heilprin was one of the earliest and most fearless investigators of Mont Pelée after the eruption of last May 8th. He arrived in Martinique on May 25th, ascended the mountain for the first time six days later, and during a second visit to the island was a spectator, and nearly a victim, of the eruption of August 30th. The work that he has produced is splendidly illustrated by reproductions of numerous photographs, and written in a style which, if it occasionally approaches that of a newspaper correspondent, is always clear and interesting. We find in it graphic accounts of a great event, of the days of preparation and neglected warnings, and of the resulting devastation of the country; and these should be sufficient to secure for the book a wide approval. The author is convinced that the principal agent in the tornadic blast of August 30th, and probably also in those of May 8th, etc., was "superheated exploded steam, charged in part with particles of incandescent or glowing matter"; and, in a suggestive chapter on Vesuvius and Pompeii, he argues with considerable force that the destruction of the latter city may have been caused by a similar explosive blast. The whole subject of the West Indian eruptions is a very wide one, in reality beyond the scope of a single investigator, and it is not therefore surprising that Prof. Heilprin should be occasionally inaccurate. For instance, some tremors recorded at Zi-ka-Wei in China are referred by him to vibrations "propagated clean through the centre of the earth," although no records of them were obtained in Great Britain, and the time interval of nearly 4½ hours was more than sufficient for even the long-period undulations to travel completely round the globe. But, notwithstanding a doubtful statement here and there and a tendency to sensational writing (*e.g.*, "the unfortunate French island, now writhing in the coils of the dragon that wrought its earlier fabric"), Professor Heilprin has written a book that can hardly fail to be of permanent value.

"Modern Microscopy." By M. I. Cross and Martin J. Cole. 3rd ed.; pp. xvi. and 292. Illustrated. (Baillière, Tindall & Cox.) 4s. net.—We heartily welcome the third edition of this now well-known work, which fills a position of its own in modern microscopical literature, and which should be in the possession of every worker with the microscope. Though modest in its apparent scope, it contains within its covers an exceptional amount of most valuable information, whilst the general arrangement and the directness and lucidity of the explanations merit the highest praise. The beginner, and he even who is not a beginner, will learn more from these pages than from more pretentious and costly volumes, he will find it an absolutely trustworthy guide to the choice of his instrument, wherein lie so many doubts and difficulties, and a careful perusal of its pages will give him an insight into and a command over the workings of the microscope which will be of the utmost value to him, whether as an amateur or as a serious student. The book is divided into three divisions. In the first, Mr. Cross takes the various parts of the microscope in their natural order; first the stand, its types, its coarse and fine adjustments, and their respective merits, the stage and sub-stage, and the refinement which modern critical work has called forth. Then follows a chapter on optical construction, which is nothing if not practical, and in which the theoretical side is confined to a series of definitions, some of which might possibly be extended with advantage. Illumination and illuminating apparatus are next dealt with, and we observe with strong approbation not only the stress laid upon the necessity for using a condenser, but the equal necessity that the corrections of the condenser should approximate in perfection to those of

XUM

the objectives. For advance in this respect, Mr. Cross rightly gives the credit to the leading English manufacturers, who have throughout seen the futility of producing an objective the corrections of which make it one of the most perfect of optical productions, and allowing it to be used in a way that practically nullifies the very excellencies for which so much is claimed. In the remaining chapter of this part accessories are dealt with in an equally satisfactory manner. In the second part Mr. Cole deals with the preparation and mounting of objects as might be anticipated in a mounter of his experience. His tables are excellent in every way, his instructions plain and unmistakable, his methods above criticism. This part of the book has a value of its own to all practical workers, and has been much extended in the present edition. Finally, a new chapter on microtomes, their choice, use, and the preparation and cutting of sections, has been contributed by Mr. G. West, of Edinburgh, which is not inferior in lucidity to the rest of the book. In the next edition we shall hope to see a further chapter on photo-micrography.

"WHAT STAR IS IT? TABLES FOR IDENTIFYING UNKNOWN STARS." By Herbert W. Harvey. (Spottiswoode.) 1s. net.—This very handy little volume is intended to assist navigators to identify stars of the second or third magnitude, the altitude of which they may have observed, and so to avoid the discarding of "sights" when the object observed is not known with certainty. It consists of a set of very neat and clearly printed tables, giving the hour angles and declinations of celestial objects for every five degrees of altitude from 10° to 65°, and for every ten degrees of azimuth. The book makes an extremely handy pocket volume, and will no doubt be very useful to many others beside navigators who wish to be able to convert right ascensions and declinations into altitudes and azimuths, or *vice versa*, where this only needs to be done approximately.

"OPEN-AIR STUDIES IN GEOLOGY." By Prof. Grenville A. J. Cole. Second Edition. Revised. Pp. 322. (London: Charles Griffin & Co.) Illustrated. 8s. 6d.—Professor Cole is so well and favourably known to readers of KNOWLEDGE that any writings by his pen are assured of a welcome. In a work of the kind under notice he is at his best. His style is popular without being childish, and accurate without being pedantic; the result is a volume which creates interest in the physiognomy of the Earth, and forms the best of introductions to the serious study of geology. Open-air studies are essential in the making of a geologist, and it is only after personal observation of characteristic rocks and scenes that a student is in a position to understand clearly their geological significance. Every intelligent observation is of sterling value in the store of a person's knowledge, and only those who have seen things for themselves can express an opinion upon them worth much consideration. As Prof. Cole remarks, "Almost all great progress in natural knowledge has thus been made by those who have seen and travelled—by those, in fact, who have studied in 'Nature's roofless school.'" His book should be the means of adding to the number of intelligent observers of the Earth's features. The text, the illustrations, and the numerous references will all help the student to understand and interpret the features of Mother Earth.

BOOKS RECEIVED.

Variations in Animals and Plants. By H. M. Vernon, M.A., M.D. (Kegan Paul.) 5s.

Ancient Greek Sculptors. By H. Edith Legge. (Unwin.) 6s.

Comets and their Tails and the Gegenschein Light. By Frederick G. Shaw, F.G.S. (Baillière, Tindall & Cox.) 2s. 6d. net.

British Ferns. By Chas. T. Druery, F.L.S., V.M.H. (Newnes.) Illustrated. 3s. 6d. net.

Chemical Technology. Vol. IV. Edited by W. J. Dibdin, F.I.C., F.C.S. *Electric Lighting*, by A. G. Cooke, M.A., A.M.I.E.E.; *Photometry*, by W. J. Dibdin, F.I.C., F.C.S. (Churchill.) Illustrated. 20s.

Triumphs of Science. Edited by M. A. Lane. (Ginn & Co.) 1s. 6d.

David and Bathshua. By Charles Whitworth Wynne. (Kegan Paul.) 5s.

How to become a Private Secretary. By Arthur Sheppard (Unwin.) 1s.

The Burlington Magazine. March, 1903. (Savile Publishing Co., Ld.) 2s. 6d. net.

The Rationale of Telepathy and Mind Cure. By C. W. Leadbeater. (Theosophical Publishing Society.) 6d.

Proper Motions of the Stars. By Gavin J. Burns. (University of Chicago Press.)

The Extension of the Foreign Trade Relations of the United States. (Philadelphia: Commercial Museum.)

Memorias y Revista de la Sociedad Cientifica "Antonio Alzate." (Mexico: Avenida Oriente 2, núm. 726.)

Report of the Advisory Board of the Commercial Museum, October 7, 8 and 9, 1902. (Philadelphia.)

Journal of the Society of Comparative Legislation. December, 1902. (Murray.) 5s.

Transactions of the City of London Entomological and Natural History Society, 1902. 2s.

Quarterly Record of Additions. No. III. By Thomas Sheppard, F.G.S. (Hull Museum.) 1d.

Short Manual of Inorganic Chemistry. By A. Dupré, PH.D., F.R.S., and H. Wilson Hake, PH.D., F.I.C., F.C.S. (Chas Griffin & Co.) 6s. net.

Papers on Mechanical and Physical Subjects. Vol. III.—*The Sub-Mechanics of the Universe.* By Osborne Reynolds, M.A., F.R.S., LL.D. (Clay.) 10s. 6d. net.

Experiments with Vacuum Tubes. By Sir David L. Salomons, Bart., M.A. (Whittaker.) Illustrated. 2s.

Report of S. P. Langley, Secretary of the Smithsonian Institution, for the Year ending June 30, 1902. (Washington: Government Printing Office.)

Raines & Co., Ealing.—Photographic Catalogue.

1903 Catalogue, Thornton-Pickard Manufacturing Co., Ltd., Altrincham.

Catalogue of The Service Photographic Society, High Holborn, London.

ST. SOPHIA, CONSTANTINOPLE.

By E. M. ANTONIADI, F.R.A.S.

Illustrated from original drawings and photographs by the Author.

III.

THE INTERIOR.

IT is from the north porch that visitors are now admitted into the mosque. They enter by the door of the celebrated "Sweating Pier," which Messrs. Lethaby and Swainson have so ably identified with the column of St. Gregory the Miracle Worker, and are then led eastwards, along the north aisle, to the sanctuary; returning by the southern division of the church. It is noteworthy that this mode of receiving tourists does not seem to have been dictated merely by the requirements of the mosque; for to guide visitors round "after the sun's path" was an old Greek tradition, to which allusion is already made in 1350 by the Russian pilgrim, Stephen of Novgorod.*

We shall not, however, adopt this course in our description. Following the emperor on feast days, we will enter the church by the Horologion, on the south side, when our attention will be at once attracted by the "Beautiful Gate" of Constantine Porphyrogenitus. The eastern panel of this door bears the inscription

ΜΙΧΑΗΛΝΙΚΗΤΩΝ

or "Michael of Victors," while the opposite panel was believed by Messrs. Curtis and Aristarches to have borne the words

ΘΕΟΦΙΛΟΥΚΑΙ

which would complete the inscription into "Of Theophilus and Michael Victors." Now, the fact that the monograms of both these emperors are also given on the panels, lends great weight to this amendment. On the other hand, we know that the names of Theophilus and Michael were often wedded together on public buildings, and Byzantios, for instance, mentions† the following inscription from the

* *Société de l'Orient Latin, Séries Géogr.*, Vol. V.

† Ἡ Κωνσταντινούπολις, Vol. I., Athens, 1857, p. 104.

land walls of Constantinople: Πύργος Θεοφίλου καὶ Μιχαὴλ πιστῶν ἐν Χριστῷ Αὐτοκρατόρων, or "Tower of Theophilus and Michael, emperors faithful to Christ."

As amended by Messrs. Curtis and Aristarches, the inscription remains, however, in the plural genitive. Such sentences are hardly sensible in English; but in Greek they are known as forms of the possessive genitive, with elimination of the associated substantive. That such elimination was actually resorted to before the words ΘΕΟΦΙΛΟΥΚΑΙ, is anything but certain. It will be seen, on the contrary—

(*a*) That the words added by the authors in question fill a much smaller space than the remaining part of the inscription, especially if the conjunction ΚΑΙ, "and," was, as usual, abbreviated into a mere Κ; and

(*b*) That in the inscription of the same emperors, quoted from Byzantios, the plural possessive case is preceded by an all-important nominative, πύργος, "tower."

The writer suggests, therefore, that the missing nominative in the south porch of St. Sophia was ΠΥΛΗ, "Gate," when, instead of the elliptical genitive "Of Theophilus and Michael Victors," the inscription would run in the cartouches

ΠΥΛΗΘΕΟΦΙΛΟΥΚ	ΜΙΧΑΗΛΝΙΚΗΤΩΝ

or "Entrance of the Victorious [Emperors] Theophilus and Michael." The reason of the absence of Theophilus's name from the western panel is perhaps not difficult to find out. By the synod of 842, Iconoclasm was declared to be a heresy, so that we should hardly expect the name of the last Iconoclastic emperor to have been tolerated in the very entrance of Orthodoxy.

In addition to this inscription and to the monograms, the panels bear the date 838 A.D., which may be rendered instrumental in establishing that the south porch existed already in 838, and that it was probably erected, with the four ascents to the galleries, by the emperor Theophilus, with a view to buttressing the angles of the church.

Just before one reaches the north exit of the porch, a little door, leading to a recess of the eastern wall, should be noted; for it was here that the emperor had his crown removed on entering the church in great ceremony.

The Grand Vestibule or *Narthex* of the west front now claims our attention. It is shorter than the church is broad, and there is no evidence showing that it was originally larger, so that the Silentiary's statement to the effect that it occupied the whole breadth of the building is a slip, the only one, however, which it is possible to find in that wonderfully accurate description.

At some distance over the lintel of the great central door, to the west, the writer has been shown four marble guns, which the Turks report to have belonged to the last Constantine. "They were not always of marble, but in metal; having been petrified at the fall of the City."

Like those of the south porch, the vaults of the Narthex are still glittering with mosaic, that most powerful element of decoration.* The identity of the fine image of the emperor kneeling before Christ, above the Royal Gate, is not known. Antony of Novgorod well says that "above the door is depicted, on a large panel, the emperor Leo the Wise," but whether allusion is here made to this door, or not, is uncertain. The medallion to the left represents the Virgin, the one to the right the Archangel Michael, and not "a winged Prodomos," as assumed by Grelot, Byzantios, and Canon Curtis. During a recent visit to St. Mark's, Venice, the writer was struck by a golden Greek eikon of Michael, with the inscription ΜΙΧΑΗΛ, said to come from St. Sophia, and which is practically identical to the medallion in question.

A restoration of the Narthex has been undertaken in Fig. 6. The appearance of the Vestibule does not seem to

Fig. 6.—The Grand Vestibule.

have been much altered since Byzantine times. No doubt the number of lamps hung from the vaults must have been incomparably greater than shown in the picture, and it is also strongly to be suspected that stalls used to stand here, at least along the western wall. It has been thought preferable, however, not to overcrowd the view with these accessories, so as to avoid seriously interfering with the perspective.

The central Royal Gate is a symbol of Christ, as the inscription above reads as follows:—"Our Lord hath said, I am the door of the sheep; by Me if any man enter in, he shall go in and out, and find pasture." A comparison of this passage with St. John's Gospel, ch. x., will show that we have here no exact transcript from the latter, but merely a combination of paragraphs 7 and 9, where the words "he shall be saved" are omitted.*

* In his *Facts and Comments*, Mr. Herbert Spencer complains of the mosaic lining of St. Paul's Cathedral, as mosaic is considered by him under the heading "Barbaric Art." Now everybody visiting Venice prefers the mosaic decoration of St. Mark's to the whitewash vaults of other Venetian churches, so that to depreciate mosaic decoration is an extravagance most distinctly antagonistic to the artistic ideas of mankind.

* Fig. 7 is a photograph by the writer of one of two Gospels coming from St. Sophia, and now kept in a Milner's safe at the Greek church of St. George, near Edirneh Kapu, Constantinople. The inside is a grand piece of penmanship with illuminated letters. The photograph shows the purple velvet cover, on which is fixed a noble crucifix in *repoussé* metal, as well as four discs representing the Evangelists symbolically by the beasts of the Apocalypse (*Revelation* iv., 6-7).

XUM

On entering from the Grand Gate, the first impression is one of vastness, as all the wide and aerial expanse of the vaults and the gorgeousness of the colonnades is at once embraced from the door. But it is especially from the centre of the west gallery, seat of the empress, that the view of the interior assumes all its grandeur. The amazed observer is at a loss as to what to admire most: the extreme beauty of the marble decoration; the harmony of the lines; the constantly receding surfaces of the vaulting, which carry the supporting parts to remoter backgrounds; or the subordination of all this to the crowning idea of symbolizing the heavens by the central dome, where Christ was depicted ruling the universe.

An unpretending attempt at a restoration of the view in question, giving a remote idea of the structure as first devised by Anthemius, will be found in Plate I., in the February number of Knowledge. The polygonal building shown in the foreground, to the left of that Plate, and inspired by the fine "Capitello" of St. Mark's,

Fig. 7.—Cover of a Gospel from St. Sophia.

Venice, marks the mouth of the cistern extending under the church. The water in this well is reported to always stand at the same level, some two yards under the floor. There is much to confirm the suspicion of Byzantios that a priest used to stand here on Sundays, blessing the people with holy water. Meantime the images of saints whose name-day it was, ought also to have been daily exposed somewhere in this part of the nave.

Grand as the present lighting of the mosque is at night time during the Rhamazan, it can scarcely stand comparison to what it was before the Latin conquest of Constantinople. The Jewish rabbi, Benjamin of Tudela, who visited St. Sophia towards 1171, after asserting that "there is no temple in the universe possessing so many riches as this one," says: "In the middle of the church are columns of gold and silver, and candelabra of the same metals in so great numbers that it is impossible to count them."* It was in three successive circles that the polycandela hung over the nave. The majority of the lamps had the form of the discs represented by Messrs. Lethaby and Swainson,† and repeated by the writer in his restorations, while the others were shaped into huge crosses.‡ Two series of openings, pierced circlewise in the vault, mark the suspension of the inner circles, while the larger circumference, almost 100 feet wide, hung from a multitude of metal hooks, which one can still see projecting from the cornice of the dome.

We are informed by Agathias that the original design of the lateral arches was different from what is now seen. However, the obscure text of the historian had led astray many a writer, so that great credit is due to Messrs. Lethaby and Swainson for having been the first to put meaning to it, and for showing what must have been the original appearance of the north and south walls of the nave.§ The writer considers the conclusions of these two authors on this point, as well as on the primitive design of the row of niches over the central colonnades of the galleries, to constitute two very important truths added to our knowledge of the church. He thought, therefore, that the best way of doing full justice and honour to Messrs. Lethaby and Swainson was to utilize their discovery in his restoration, and to cheerfully acknowledge the fact in this description of his Plate of the interior, published in the February number of Knowledge.

Theophanes tells us that the original dome was flatter by 20 feet than the present one, and Zonaras increases this to 25. To render these data intelligible, the investigator should consider the probable requirements with which the architect must have been confronted. These seem to have been:—

(*a*) The desire of having an "aerial" dome, *i.e.*, borne on pendentives, but not constituting their continuation;

(*b*) The advantage of a cornice at its base for the lamplighter;

(*c*) The placing the centre of the dome's curvature at the height of some important architectural feature of the design; and

(*d*) The necessity of giving the total altitude of the church a round number of Byzantine feet.

A continuous pendentive cupola is most unlikely, as it would be some 29 feet flatter than the present one—a value which historical data contradict—and also for the reason that it could not satisfy (*a*) and (*b*) of the preceding requirements. Of the two historians mentioned, Theophanes is the more trustworthy. It will be seen that Zonaras makes the height of the building 155 feet; but, though his dome becomes parallel to the spherical surface generated by the pendentives, the fact that the cornice is rendered impossible is a grave objection to the veracity of his value. On the contrary, the dome of Theophanes fills all the above conditions: it rests on the pendentives, without forming their continuation; it leaves room for the lamplighter; has its centre at the level of the culminating

* *Voyage de Rabbi Benjamin, Fils de Jona de Tudele*, transl. by Baratier, Amsterdam, 1734, pp. 46–47.

† *S. Sophia*, p. 112, Fig. 16.

‡ The splendid cross under the west dome of St. Mark's, Venice, is of Greek workmanship, and, most probably, comes from St. Sophia.

§ *S. Sophia*, pp. 212–214.

point of the eastern apse; and carries the altitude to 160 feet—a round number, and a multiple of the number 40, so frequently met with in Byzantine architecture. It was evidently for the sake of the "aerial" cupola and of the cornice that the idea of a continuous pendentive dome

Fig. 3.—Capital of one of the Great Columns of the Nave, with the Monogram of Justinian.

was rejected. Under the existing circumstances, however, such aerialty was not to be obtained in connection with a flat dome, except at a tremendous cost of solidity. The thrust exerted by the over-daring cupola of Anthemius on the piers and semi-domes was so overwhelming that a catastrophe through failure of some point of the supports could not long be averted.

It is generally believed that Paul the Silentiary does not mention any mosaic images on the vaults in 563. Such, however, is not the writer's impression. The poet's description of the dome has not been preserved intact; there is a lacuna in the Greek text from verse 80 to verse 92, and, amid the *débris* of words, overlooked by all authors, we find:—

90. . . . . ἔνδοθι κύκλου
91. . ψηφίδ . . . ὅ'φρα σαώσῃ
92. . ειφρουρ . . κόσμοιο σαωτήρ,

that is, in English:—

"In a circle—mosaic—in order to save—always well guard {ing / ed}*—the Saviour of the World."

The *Painter's Manual* recommended to "draw near the summit of the cupola a circle of different colours. . . . In the centre represent Christ with the Gospel, and this inscription: 'Jesus Christ the Almighty.'" And it is evident that the great analogy between this description and the few remnants from the broken verses constitutes a positive proof of the important fact that the Pantocrator has adorned, from the very onset, that most genuine representation of the flattened vault of heaven.

(To be concluded.)

* The remnant ειφρουρ seems to be some combination of ἀεί, "always," and φρουρέω "I guard." The adjective, in poetic language, is ἀείφρουρος or ἀειφρούρητος.

MICROSCOPY

Conducted by M. I. Cross.

NOTES ON THE COLLECTION, EXAMINATION AND MOUNTING OF MOSSES AND LIVERWORTS.

By T. H. Russell.

(Continued from page 70.)

As far as my acquaintance with glycerine jelly goes—and it is one of a good many years' standing—the great objection to its use arises from the fact that after a specimen has been mounted in it, and has stood possibly for years, the jelly may develop an unpleasant tendency to liquefy, as will be evidenced by the presence of small beads of glycerine round the edge of the cover-glass. Moreover, this seems to come about without its being possible to track the cause of the mischief. For instance, I have slides which were put up twenty years and more ago, and which have never shown any signs of deterioration, while others, which have lain side by side with these, and which did not date back nearly so far, have had to be discarded as failures. Some time ago I had the misfortune to lose a large portion of my then small collection in the above manner, and since then have constantly been on the look-out for indications as to how such an occurrence could be avoided in the future. While not being able, so far, to suggest any unfailing remedy, I have come to the conclusion that there are, nevertheless, a few simple rules the careful observance of which will considerably minimise the risk of such a disappointing experience as that to which I have alluded. These are:—

1. Care should be taken to remove the preparatory fluid from the surface of the object, as far as possible, before mounting.
2. No pressure should be applied to the cover-glass in order to keep it in position, its own weight being alone sufficient for the purpose.
3. A sufficient quantity of the jelly should be used to allow of a small portion extending on every side beyond the edge of the cover-glass.
4. The slide should stand for at least two or three months before the additional jelly is removed and the cell sealed, as this ensures the due contraction of the jelly.
5. The slides should not be kept in a draughty position.

During the past few years I have frequently used formalin in my mounts, and up to quite lately, with what seemed to be most satisfactory results. My *modus operandi* has been as follows:—While the slide is on the hot-water bath, with a small pool of melted jelly on it, ready to receive the object, I drop into the jelly, from the end of a thin glass rod drawn to a point, a drop of 40 per cent. solution of formalin; then quickly mix this with the jelly by the help of a dissecting needle, arrange the object and place the cover-glass in position. All these latter steps have to be carried out with considerable expedition, on account of the speed with which the jelly sets when once the formalin is added. After the slide has cooled, the jelly will be found to have solidified into a firm compact mass, and whereas in an ordinary mount a moderate degree of heat would suffice to re-melt it, now even soaking in boiling water has no such effect. The binocular dissecting microscope

will be found especially useful in this process, as the lenses form a good screen for the eyes from the otherwise too pungent fumes of the formalin.

It occurred to me that possibly the formalin might injuriously affect the delicate cell structure of the moss leaves, but experiment assured me that this need not be feared, and I began to hope that here, at least, was a method of mounting that would practically eliminate all serious risk of failure. My disappointment was consequently great when, on going to my cabinet a couple of months ago, I found that several of the slides mounted with formalin had gone wrong. What puzzles me all the more is that slides in the same drawer, put up some with formalin and some in the ordinary way, show no sign of change. Thus slides of *Hypnum, Commutatum* and *Andreæa alpina* mounted five or six years ago give no indication whatever of deterioration, while others, completed fully twelve months since, and which have purposely been allowed to stand in a room without a fire, are still in a perfectly satisfactory condition. Moreover, in January, 1902, I put a few drops of the jelly on a glass slide, and mixed with them a little of the formalin solution; this slide has also laid in a room without a fire, and the jelly, though unprotected by a cover-glass, is still compact and firm. The drawer containing the specimens in question happens to be the one nearest to the ground, and the cabinet stands in a corner of my dining-room furthest removed from the likelihood of draught, but as the door of the cabinet fits closely, it is difficult to believe that change of temperature constitutes the explanation, especially as the slides in the drawer not far above the one in question are unaffected. I have recently been making still further experiments, though sufficient time has not yet elapsed for any definite conclusions to be drawn from them; on the whole, however, I am inclined to think that too much formalin was used in the mounts referred to, and that herein lies the cause of their failure. Of late, therefore, I have dipped little beyond the extreme point of the glass rod into the formalin solution, thus transferring a much smaller quantity to the jelly in the cell; this will not, of course, solidify the jelly so thoroughly as if the larger quantity were used, but, on the other hand, it will not have the same contractive power.

In concluding these notes, let me again emphasise what I said at the outset, namely that they have been written in the hope that others may thereby be induced to give the results of their experiments in the matters of which they treat, a remark which specially applies to the somewhat full details given with regard to the use of formalin. I am well aware that much that they contain will certainly not be fresh to many workers, yet possibly for some who have not long taken up the study, there may be in them a few practical hints which will be of service.

THE MOUTH PARTS OF THE TSETSE FLY.

By W. Wesché, F.R.M.S.

It cannot be denied that it would be difficult, if not impossible, to find a more destructive instrument than the proboscis of the Tsetse fly (*Glossina*). Yearly it causes the death of large numbers of horses and cattle, and whole districts, one might say whole provinces, are depopulated on account of its presence. Yet the part itself is innocent and interesting; were it not for the parasitic habits of certain lowly organisms it would be quite innocuous. We see this clearly enough when we examine our English relatives of the Tsetse fly, *Stomoxys calcitrans, Hæmatobia stimulans, H. irritans* and *Prosena sybarita*.

Apart from its character as an organ of destruction the proboscis of Tsetse has interest; we can trace its development through several stages back to a trophi similar to that on our common larger house fly. In its case, as in all, the rule of the French *savant* Savigni holds good, "the organ is the same in all insects, it is only the use that is changed or modified." By examination of the structures and parts in many species it appears that Tsetse as a species is a comparatively recent addition to our fauna, which has developed a peculiar mouth part for a special purpose. In our larger house fly (*Musca domestica*) the proboscis is a suctorial organ, with the ordinary characters of such a mouth part as found in Diptera, that is to say, the outer and inner jaws (the mandibles and maxillæ) which we find in the gnats (Culicidæ), the breeze flies (Tabanidæ), and other biting insects, have been absorbed into the lower lip (*labium*), and now act as stiffening rods and levers to support the two suctorial discs (*paraglossæ*) at the extremity of the lower lip. The discs or *labella* are fitted with symmetrical rows of trachæ, or tubes formed of chitinous rings.

The lower lip has on its under or ventral surface a chitinous place (the *mentum*) which forms a support. Above the lower lip is the *labrum* or upper lip, which has, however, its base enveloped by the membrane of the lower lip. The upper lip in Diptera is a horny lancet case, which covers a lancet (the *hypopharynx*), which corresponds with the *lingua* or tongue.

The upper lip is furnished with two feeling organs (the *labial palpi*). Till lately these were thought to belong to the inner pair of jaws (*maxillæ*), but the discovery of complete palpi on many species enables me to say with certainty that these are labial, or belonging to the lower lip.

(*To be continued.*)

MONOCHROMATIC LIGHT (*Continued*).

Beyond this, and of greater importance, is the equivalent effect which can be secured with a good achromatic lens—equal, in fact, to that with an apochromatic. All residual colour in the lens is absorbed by the one colour of the light filter, so that the great difference between the chromatic and apochromatic systems, namely, the outstanding secondary spectrum, is thereby abolished.

If all the colours of the spectrum are used in their proper succession to illuminate a given object, it will probably be found that a re-focussing is necessary for many of them, the greatest amount of variation being noticeable usually at the two ends of the spectrum.

Mr. Nelson some years ago prepared a series of charts in which this subject was exemplified with a variety of lenses. In every lens the point of least chromatic aberration is indicated by the focal point remaining practically the same for a continuous range of colour rays. This same point will be the one of least spherical aberration also if the optician has done his best. If, now, a colour screen is selected which approximates to the mean of the portion of the spectrum which exhibits the least difference of focus, and therefore the smallest amount of spherical aberration, the best result would be obtained with the objective.

Before giving formulæ for making fluid monochromatic light screens, the method adopted by Dr. Spitta for obtaining his monochromatic light, as exhibited at the Royal Microscopical Society recently, may be of interest. The following was the system used in the order of arrangement:—

1. Oxy-hydrogen limelight;
2. A condenser composed of two plano-convex lenses, having placed between them a water bath;
3. A slit;
4. An achromatic collimating lens of about 6″ focus, composed of a double convex and plano-concave lenses cemented;
5. A prism, having mounted on one of its faces Thorpe's grating, so arranged as to obtain direct vision for the F line;
6. A concave lens immediately behind a substage condenser, the object of which is to render the rays divergent, so as to suit the flame distance for which the substage condenser is corrected;
7. A holoscopic oil-immersion condenser.

Fluid Screens.—One of the most useful screens is that which is known as "Gifford's," and is made by dissolving a few crystals of malachite green in glycerine. The solution is examined spectroscopically with the illuminant that is to be employed, and green is slowly added until the red end of the spectrum is entirely absorbed. It should be noted that a piece of signal green glass in conjunction with this solution materially reduces the thickness of the trough that would otherwise be required. (*To be continued.*)

"THE JOURNAL OF APPLIED MICROSCOPY AND LABORATORY METHODS."

For five years past there has been published at Rochester, New York, U.S.A., a journal with the above title. As this title implies, it is essentially technical and practical.

I have before me a bound volume for the year 1902, and the ground covered by the various articles is very wide and full of interest for microscopists.

The future of microscopy is not dependent on the amateur who only examines ready-prepared micro slides, but on him who practises known methods and endeavours of his own initiative to find better ones. To such this journal in particular appeals.

NOTES AND QUERIES.

J. H. Garnar.—I have not heard of an English edition of Lilljeborg's "Cladocera succiae," and it seems unlikely that such a work will ever be issued. I may mention, however, that at the meeting of the Quekett Microscopical Club on January 16th, Mr. Scourfield brought forward the first part of a synopsis of the British species of fresh-water Entomostraca, in which he dealt with the Cladocera, taking Lilljeborg's book as the work of reference, both for descriptions and figures of the large majority of our species. It seems probable, therefore, that the "Cladocera succiae" will become an indispensable book for British students of these interesting animals, and I certainly have no hesitation in recommending it in spite of its being written in Latin and German, and being somewhat expensive. After all, we in this country ought to be thankful that the veteran Upsala professor did not write his great work in Swedish.

A. W. Comber (India).—It is impossible to advise you as to a course of study which you could pursue on parallel lines with your professional work without knowing the direction in which your tastes and inclinations lie. You would find metallurgical work, that is, the study of the composition and surface of metals, exceedingly interesting, and probably the best book on the subject is Hiorn's, entitled "Metallography." Or perhaps geological and petrological work would prove suitable. You would find a very large and entertaining field in either department.

Roger.—The fractions of an inch by which objectives are designated express approximately the magnifying power or equivalent focus, and not the distance at which they focus from the object. The equivalent focus of an objective divided into 10 gives its magnifying power, thus a 2 inch should magnify 5, a $\frac{1}{4}$ inch 40, and $\frac{1}{8}$ inch, 80 diameters. The troubles you refer to in connecting with your mounting are such as all tyros have to face, practice alone will make you expert. If you cannot obtain guidance from the books you refer to, it would be impossible to give it in a short answer. The assistance of a microscopical friend would probably clear the way.

J. G. Leigh.—Probably the book that would suit you would be Wood's "Common Objects of the Microscope," costing 1s.; or Cooke's "One Thousand Objects for the Microscope," price 2s. 6d.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. Cross, Knowledge *Office, 326, High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

Perrine's Comet (1902 b).—This object has now passed beyond the range of ordinary instruments, though it may possibly be still visible in some of the largest telescopes. Mr. F. H. Seares, of the Law's Observatory, Missouri, has computed the following elements:—

PP. 1902, November 23·90094, Berlin M.T.

	°	′	″
ω	154	1	34·4
Ω	49	20	11·0
i	156	20	56·1

log. q. 9·612596
log. e. 9·999709.

The form of orbit shows a scarcely perceptible deviation from that of a parabola.

Giacobini's Comet (1902 d).—This distant and apparently very small comet continues visible in a good telescope, but its light is gradually declining, and it will soon withdraw from view. At the close of April it will pass near the bright star Castor (α Geminorum), but the comet will be rather a difficult object at about this period in telescopes of moderate size, and will have to be swept for very carefully.

Giacobini's Comet (1903 a).—This comet is considerably brighter than when first discovered on January 15, but its position is too near to the sun for it to be well seen.

Meteoric phenomena have recently been reported as follows:—

February 2, 4 a.m.—A large detonating meteor burst over a point about 2 miles south of Anderson, California, and is described in the *Daily Telegraph*. The roar which accompanied the passage of the fireball startled the townspeople, who ran into the street for safety, thinking that the vibrations were due to an earthquake. Some of the buildings were damaged.

February 2, 6h. 20m. p.m.—Commander Neate, R.N., writes from Dover that he observed a meteor brighter than Venus moving from near the Polar Star to δ Ursa Majoris. The apparition suggested to his mind "a brilliant jewel at the end of a long chain." Duration $1\frac{1}{2}$ seconds.

February 4, 7h. 7m. a.m.—Large and brilliant meteor seen in the west from Yalding, Kent, by Mr. W. Jarvis.

February 12, 6h. 54m. p.m.—Meteor equal in lustre to Jupiter, seen at Liverpool and moving horizontally at an altitude of about 30 degrees in a northerly direction. Alpha Cygni was just below and midway in its course, which occupied about 5 seconds.

Recently in Cape Colony (date not given), "at 10 p.m. a sudden rumbling and hissing noise was heard, and a tremendous ball of fire was seen falling towards the earth, its velocity being so great that it gave the appearance of a burning gash in the sky. As it reached the ground several explosions took place, and next day a large black stone was extracted from a hole 2 feet deep and 2 feet wide, which the body had made."

February 17, 9h. 45m.—Brilliant meteor, giving as much light as the moon in her first quarter, seen at Beckley, Sussex, by Mr. R. Forbes Bentley, but trees hid the latter part of the flight. Observed path from 172½° + 20° to 195° + 15°. Duration about 2 seconds.

February 22.—At Ramsay, Isle of Man, there was a very severe gale during which a huge fiery meteor passed over the town lighting up everything like day.

February 26, 7h. 45m.—A large white meteor observed at Hammersmith, W., by Mr. E. Delessert. Its course carried it overhead in a direction from S.E. to N.W., and its approximate flight of 100 degrees occupied 3 to 4 seconds.

April Lyrids.—This shower should be carefully looked for on April 21 and 22, though it seldom furnishes a rich display. This year there will be very little interference from moonlight, so that with clear skies the meteors ought to be favourably observed. Their radiant point, like that of the July-August Perseids, exhibits motion to the eastwards, and as it is essential to obtain more evidence on this point, any earlier and later members of the stream (appearing on April 17-19 and 23-25 respectively), should they be presented, will deserve special notice, and their apparent paths amongst the stars if registered with the greatest possible accuracy will be very valuable.

May Aquarids.—At the end of April and opening of May it will be necessary to watch the eastern quarter of the firmament for the long-pathed, streak-leaving Aquarids first seen by Lieut.-Colonel Tupman in 1870. The radiant point of this shower has never been fully ascertained, and it is hoped that a large amount of new data will be obtained during the ensuing few years.

THE FACE OF THE SKY FOR APRIL.

By W. Shackleton, F.R.A.S.

The Sun.—On the 1st the sun rises at 5.41 and sets at 6.29; on the 30th he rises at 4.39 and sets at 7.17.

The equation of time is negligible on the 16th, this day therefore is favourable for the checking or adjustment of sun-dials by comparison with civil time, since only the correction for longitude need be taken into account. Sun-spots are now of more frequent occurrence, and of late two or more spots have been visible at one time.

The Moon:—

		Phases.	h. m.
April	5	☽ First Quarter	1 51 A.M.
,,	12	○ Full Moon	0 18 A.M.
,,	19	☾ Last Quarter	9 30 P.M.
,,	27	● New Moon	1 31 P.M.

The moon is in perigee on the 5th, and in apogee on the 19th.

XUM

Occultations.—The principal occultations visible at Greenwich are as follows:—

Date.	Star Name.	Magnitude.	Disappearance.			Reappearance.			Moon's Age.
			Mean Time.	Angle from N. Point.	Angle from Vertex.	Mean Time.	Angle from N. Point.	Angle from Vertex.	
			h. m.	°	°	h. m.	°	°	d. h.
April 3	130 Tauri	5·5	6 47 P.M.	128	102	7 44 P.M.	239	204	5 18
,, 6	A^1 Cancri	5·6	5 46 P.M.	76	102	6 50 P.M.	315	328	8 17
,, 6	A^2 Cancri	5·8	8 8 P.M.	138	133	9 11 P.M.	259	239	8 19
,, 7	60 Cancri	5·7	0 44 A.M.	81	41	1 34 A.M.	314	275	9 0
,, 9	ν Leonis	4·5	11 48 P.M.	177	161	0 23 A.M.	233	211	11 23
,, 10	B.A.C. 4300.	5·7	9 58 P.M.	95	109	11 8 P.M.	315	315	12 21

There is a very favourable eclipse of the moon on the 11th, when the moon is nearly totally eclipsed. The diagram, projected in the manner described in Knowledge, October, 1902, shows the path of the moon through the earth's shadow.

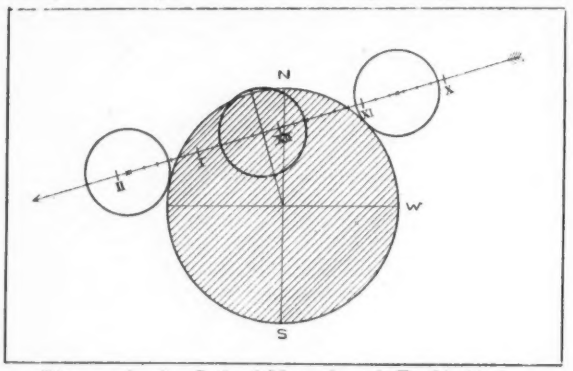


Diagram showing Path of Moon through Earth's Shadow.

The following are the particulars of the eclipse:—

			H. M.	
First contact with the Penumbra	...	April 11,	9 28	P.M.
First contact with the Shadow	...	,, 11,	10 34	P.M.
Middle of the Eclipse	...	,, 12,	0 13	A.M.
Last contact with the Shadow	...	,, 12,	1 52	A.M.
Last contact with the Penumbra	...	,, 12,	2 58	A.M.

Magnitude of Eclipse (Moon's diameter = 1) 0·973.

The Planets.—Mercury is unobservable during the former part of the month, being in superior conjunction with the sun on the 13th. Towards the end of the month, however, he is becoming well situated for observation, as he sets nearly two hours after the sun.

Venus is now the most brilliant object in the western sky, and shortly after sunset cannot fail to attract attention. On the 1st she sets at 9.17 P.M., and on the 30th about 10.45 P.M., or nearly 3½ hours after the sun. The apparent diameter of the planet is now 12″·6, and the disc presents a fairly gibbous appearance, the illuminated portion being 0·8 of the whole.

Mars is now available for observation throughout the night. On the 15th he is on the meridian at 10.36 P.M., preceding Spica by about an hour. He is describing a retrograde path not far from γ Virginis. The apparent diameter of the planet is 14″·6, whilst 0·985 of his disc is illuminated. The north polar cap of the planet is presented towards us. At 7 P.M. on the 10th the moon will be near to Mars, the planet being about 4° to the north.

Jupiter, Saturn, and Uranus are all practically out of range, rising in the early morning about 4, 3, and 1 A.M. respectively; the latter two are also exceptionally low down in the sky.

Neptune is observable in the evening, and is situated in Gemini; he is close to η Geminorum, being only 4 minutes west and 10′ south of that star.

The Stars.—About the middle of the month at 9 P.M. the positions of the principal constellations are as follow:—

Zenith . Ursa Major.
North . *Polaris*; to the right, Ursa Minor and Draco; to the left, Cassiopeiæ and Perseus; below, Cepheus and Cygnus.
South . Leo and Hydra; to the south-east, Virgo; to the south-west, Gemini (high up), *Procyon* and *Sirius* (setting).
West . Taurus, Pleiades and Orion, all rather low down.
East . *Arcturus*, Corona, and Hercules; to the north-east, *Vega* rising.

Minima of Algol occur on the 6th at 10.11 P.M., and 9th at 7 P.M.

Chess Column.

By C. D. Locock, B.A.

Communications for this column should be addressed to C. D. Locock, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of March Problems—(By J. C. Candy).

No. 1.

1. B to Kt6, and mates next move.

[Several solvers appear to have overlooked the fact that the Black Bishop defends the QBP. Hence, other moves with the Bishop are unavailing.]

No. 2.

1. R to Kt3, and mates next move.

Solutions received from "Alpha," 0, 2; W. Nash, 2, 2; G. A. Forde (Capt.), 0, 2; W. Jay, 2, 2; "Looker-on," 2, 2; A. H. H. (Croydon), 2, 2; W. H. S. M., 2, 2; G. W. Middleton, 2, 2; "Tamen," 2, 2; "Quidam," 2, 2; J. W. Dixon, 2, 2; C. Johnston, 2, 2; H. F. Culmer, 0, 2; G. P. Burns, 2, 0.

W. Geary.—Very many thanks. Two of them will appear next month, and the remainder during the summer.

G. P. Burns.—In No. 2, if 1. P to R6, B to K3; if then 2. Kt to K4, B to R7, or if 2. P to R7, B to Q4. 2. Kt × B is, of course, stalemate.

Hamilton White.—Please send the actual solution of your end-game. There is a mate in seven moves in which all Black's moves are not forced. I am uncertain, therefore, whether this is your intended solution.

H. F. Culmer.—Thanks for the problem; I fear, however, that it would never do to use in a solution tourney a problem which has already been published.

"*Quidam.*"—I am forwarding your complaint as to lateness of delivery, and hope that the matter may be remedied in future.

"*Tamen.*"—Please see reply above. You must understand, however, that rules cannot be relaxed to suit special cases, otherwise there might be no limit to the number of extenuating circumstances which might be urged.

A. H. H. (Croydon).—Many thanks for the problem. I will examine it, but cannot say for certain in what number it will appear.

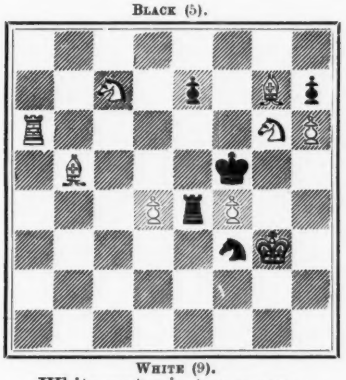
Solution Tourney.—The leading scores at present are:—J. W. Dixon, C. Johnston, W. Jay, "Looker-on," W. H. S. M., W. Nash, 22; "Quidam," 19; G. W. Middleton, 18; "Endirby," 18 (no solutions received this month).

PROBLEMS.

By C. D. Locock.

No. 1.

Black (5).

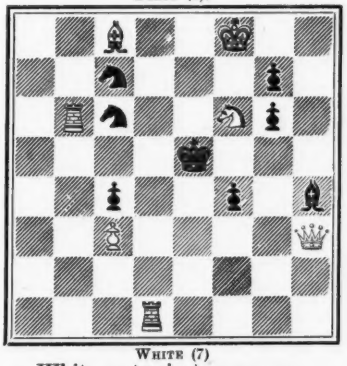


White (9).

White mates in two moves.

No. 2.

Black (8).



White (7)

White mates in two moves.

After this number I shall hope to give at least one three-move problem every month.

"KNOWLEDGE" PROBLEM TOURNEY.

After careful consideration I have placed the eight problems, selected by the more successful solvers, in the following order :—

1st. *No.* 12, "*Ariadne.*"—A problem with many beautiful points. The key, perhaps, is rather more "take" than "give," but as Black could evidently not take the Knight where it stands, I cannot consider it weak. Three out of the four continuations are quiet, one being a Queen sacrifice. Very pretty is the successive visitation of Q3, QB3, and QKt3, and the use of the Black Bishop to block the King in two different mates. It is a pity that a third attempt of this kind results in a dual or triple mate. Very pleasing too is the distant action of the White Bishop, with its one "Ruy Lopez" mate. The great variety after 1. . . . B × P is probably due to the fact that the problem, though it simulates a "block," is in reality of the "threat" class. Q to R8 is a good "try," the White King being cleverly used to prevent its becoming too good. Q to KKt3 and P to B4ch are also fair "tries." Every piece, and one of the rather numerous White Pawns, gives a mate.

2nd. *No.* 26, "*Ben trovato.*"—An ideal light-weight problem. The substitution of a Rook (which mates on three different squares) for the customary Knight or Bishop is most refreshing. The key is distinctly difficult, and good to the extent of giving additional freedom to the Black King. Of the six continuations two are quiet, though confining, and many of the mates are good, while none are absolutely commonplace. The one weak point is the uselessness of the White King. Its position may serve to call attention from the key, but its proper place, if possible, was at QR8, removing one of the Black Pawns. But for this the economy is almost perfect. The White Knight is curiously stationary throughout.

3rd. *No.* 10, "*Possibilities.*"—A very pretty position. The two continuations with the Knight, which makes the key, are in excellent style, and P to B3 is a subtle defence to the threat. Some of the mates are admirable. There is rather less variety than in the other prize-winners. The composer probably found some difficulty in stopping a dual, but in other respects the construction is first-rate.

4th. *No.* 18, "*Bargany.*"—A slashing problem, with much bloodshed on both sides. I cannot consider the key good. Though the Rook is offered it was already *en prise*, and the square given to the Black King is not sufficient compensation for the square of which he is robbed. The threat is, nevertheless, not obvious, and results in a great variety of rather inferior mates. The two main variations, involving the sacrifice of Queen and Rook, are very brilliant; other continuations are moderate, and lead to mating positions in which one or more of the White pieces have no part. There are some dual mates in two of the variations. The economy of White force is by no means satisfactory, and only three of the mates are at all pure and economical. Particularly annoying is the position of the Black Knight when the King is mated at K5, and of the Pawn at Kt3 when he is mated by Kt to Kt7. The White King guards one square in one continuation, but takes part in no mate. This problem was easily first in the estimation of our solvers. For this reason I have, in these remarks, dwelt more on what seem to me its defects than on its many good points.

Equal 5th. *No.* 13, "*Leonard.*"—Distinguished above all others for the purity and economy of the mates. The key is good, followed, as it is, by a quiet threat; though the piece to move is, perhaps, rather obvious. There is a fine try by 1. Kt to B5. But for the unfortunate dual after K to Q3 this problem would probably have been a prize-winner. As it is, it must be content with honourable mention.

Equal 5th. *No.* 4, "*Three Steps and a Shuffle-off.*"—A well-constructed diagonal flight-square problem of not unfamiliar type, with three quiet continuations and some very nice mates. The key lacks difficulty, and, moreover, deprives the Black King of what was clearly his best chance of ultimate escape. The economy is of course quite faultless.

7th. *No.* 24, "*Weighty.*"—An ingenious "block," but Black's threatened check and the position of the Black Bishop both aid in the quick discovery of the key, the brilliancy of which is somewhat discounted by the fact that the Queen is out of play. The subsequent continuations, including the Queen sacrifice, strike me as a little obvious; the best variation follows on 1. . . Kt × Q, which leads to two capital mates. The remaining variations are only of a moderate character, and more than one White piece is generally "looking-on" at the mate. Q × P and B to Bsq are fair "tries."

8th. *No.* 6, "*Trifolium duplex.*"—The main feature consists in the mates given by three White Pawns, in one case by promotion. The key would be good if it did not threaten a mate on the move, and Black is provided with

an abundance of defences. The Queen sacrifice leads to a pure mate; but even here three White pieces, besides the King, are mere spectators. The other mates are for the most part very impure. Altogether the position is greatly overcrowded, and the absence of a second solution is really surprising.

The best of the other sound problems, mentioned in order of publication, are, I think, No. 1, "Per Aspera ad Ardua"; No. 9, "Satis" (a good problem, but our solvers evidently will not stand the minor duals inseparable from compositions of the German school); No. 17, "Brutum Fulmen"; No. 22, "By indirection, etc." (very good but for the triple continuation after 1. . . B to B6); No. 23, "Seeing the thing through" (a very clever and original piece of work, but the key is weak, and, again, the minor duals were against it), and No. 25, "Inter Pocula" (*see* note on No. 9).

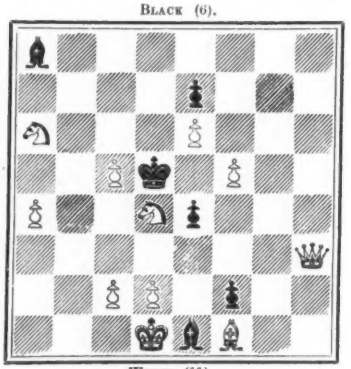
Of the unsound problems, No. 2, "Fort Nachanand," was a truly magnificent conception, the "race of the Knights" being distinctly humorous. No. 11, "With how much labour, etc.," was also a fine problem, the composition of the winner of the last KNOWLEDGE tournament.

On opening the sealed envelopes, I find that the following are the prize-winners. The award, as usual, will remain open for one month.

FIRST PRIZE.—"Ariadne."

By G. Heathcote (Manchester).

BLACK (6).



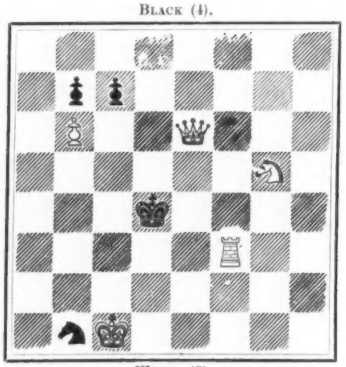
WHITE (11).

White mates in three moves.

SECOND PRIZE.—"Ben trovato."

By W. GEARY (London).

BLACK (4).



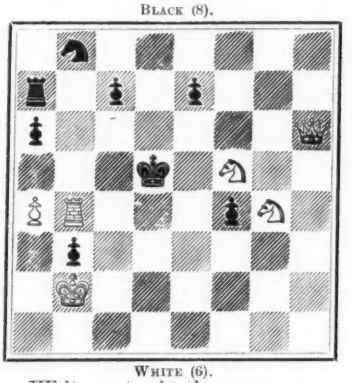
WHITE (5).

White mates in three moves.

THIRD PRIZE.—"Possibilities."

By H. F. W. Lane (Stroud).

BLACK (8).



WHITE (6).

White mates in three moves.

The following problems (given in Forsyth notation) obtain honourable mention:—

No. 18. "Bargany" (F. W. Wynne, Dudley)—2 B 1 N 1 K 1, 1 r 1 p p 3, b R 4 p 1, 3 k 4, Q 1 p 2 P p 1, 1 R 2 B n 2, 8, 8.

No. 13. "Leonard" (B. G. Laws, London)—4 K 2 b, 1 p 5 P, 1 P 6, 3 B k 3, 1 p P 1 N 3, 5 Q 2, n 1 P 5, 8

No. 4. "Three steps and a shuffle-off" (G. J. Slater, Liverpool)—8, 8, 4 p 3, 1 P k 1 N 2 Q, 8, 2 N 5, 8, 2 K 5.

The composers of the remaining problems were as under: those marked with an asterisk proved to be unsound. 1, P. L. Osborn (London); 2,* K. Erlin (Vienna); 3, E. G. B. Barlow (Surbiton); 5,* E. Palkoska, (Bohemia); 6, R. J. Bland (India); 7,* J. Möller (Denmark); 8, A. P. Bree (Jersey); 9, J. Jesperson (Denmark); 11,* A. G. Fellows (Watford); 14, Rev. R. J. Wright (Worthing); 15,* H. W. Schmidt (Honolulu); 16, V. de Barbieri (Russia); 17, Horace Pitt (Cardiff); 19, J. W. Dawson (Grimsby); 20, Max J. Meyer (Boscombe); 21,* R. H. Andrews (Jersey); 22, Percy Healey (London); 23, J. W. Abbott (London); 24, P. G. L. F. (Twickenham); 25, R. Hollstein (Berlin).

It is rather remarkable that no Continental composer received a single vote from any of the solvers who acted as preliminary judges.

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